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# Learning outcomes as affected by teaching mode and field-dependence-independence

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MODE AND FIELD-DEPENDENCE-INDEPENDENCE.

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Learning outcomes as affected by teaching mode  
and field-dependence-independence

by

Helen Pyle Njus

A Dissertation Submitted to the  
Graduate Faculty in Partial Fulfillment of  
The Requirements for the Degree of  
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## INTRODUCTION

A goal of education is to prepare individuals to deal satisfactorily with the complexities of the world. A multitude of teaching modes have been employed to reach this goal. Frequently the success of these methods is judged in terms of student performance on subject matter achievement tests. Another criterion on which to base the selection of teaching methods is the extent to which the classroom experience facilitates thinking. The latter appraisal is of greater importance than the former to educators who believe that the primary goal of education is to promote independent thinking. Spitze (1968) recommended that processes and skills basic to productive inquiry take precedence over content. Both criteria, subject matter achievement and mastery of thinking skills, must be considered in evaluations of methods for teaching today's learners.

It is naive to assume a stable correlation between a mode of teaching such as expository or guided discovery and learning for all students. Dimensions of the effects of different modes of instruction for different individuals have been explored, but the need is to consider different effects which typically may exist for learners with different personality traits. It is probable that different traits within learners are likely to be accompanied by different outcomes when the teaching mode is varied (Berliner & Cahen, 1973). Berliner and Cahen also predicted that trait treatment interaction studies will make important contributions to educational research.

A trait which logically seems to have potential for interacting with different teaching modes is the cognitive style of field-dependence-independence. Links of the trait with an individual's social behavior have been reported by Witkin (1973). Expository and guided discovery modes of teaching may be contrasted and found to favor different types of social behavior (Bodine, 1975). Thornell's (1976) recent review substantiates the need for cognitive style research on which to base curriculum decisions.

The learner's cognitive style may predispose the learner to greater achievement on particular learning tasks. Guetzkow (1951) reported that the more analytical or field independent the learner, the greater the success in problem-solving. The relationship of the field-dependence-independence variable and learning, and its interaction of field-dependence-independence with instructional methods has yet to be determined (Grieve & Davis, 1971).

The purpose of the present study was to compare expository and guided discovery teaching modes with respect to learning outcomes for students who differed on the trait of field-dependence-independence. The learning outcomes of interest were subject matter achievement and mastery of inquiry process skills.

The specific hypotheses tested were:

- 1a. Mastery of inquiry process skills is the same whether the teaching mode is expository or guided discovery.
- 1b. Mastery of inquiry process skills does not depend on performance on the Hidden Figures Test.



- 1c. Mastery of inquiry process skills does not depend on past academic achievement as measured on the Iowa Test of Basic Skills.
- 2a. Subject matter achievement is the same whether the teaching mode is expository or guided discovery.
- 2b. Subject matter achievement does not depend on performance on the Hidden Figures Test.
- 2c. Subject matter achievement does not depend on academic achievement as measured on the Iowa Test of Basic Skills.
- 3a. Mastery of inquiry process skills is the same for relatively field-dependent and field-independent learners whether the teaching mode is expository or guided discovery.
- 3b. Subject matter achievement is the same for relatively field-dependent and field-independent learners whether the teaching mode is expository or guided discovery.

A subject matter test was developed for the study based upon energy management modules. The modules were used as a guide to implement instruction in one or the other of two teaching modes.

Classes of home economics students constituted the sample for this study. The research design recognized the importance of using classrooms as the observational unit in this field research. The analysis was appropriate for exploring the influence of the field-dependence-independence trait on learning outcomes for the two teaching modes.

This study was planned to contribute to a long-range study of different instructional strategies being conducted by the Department of Home Economics Education. Looking at cognitive style was a new dimension of the ongoing exploration of factors which may contribute to the acquisition of higher-level cognitive skills. The study was funded in part by the Home Economics Research Institute and the Graduate College. The specific objectives of the study were:

1. To determine if classrooms of learners which were taught in an expository mode differed from those taught in a guided discovery mode on measures of inquiry process or subject matter achievement, and
2. To identify a possible trait treatment interaction of the learners' cognitive style with an expository or guided discovery teaching mode.

#### Definitions

Classroom teacher: The instructor regularly assigned to the class participating in the research by the public school administrators.

Field-dependence-independence: The cognitive style variable which describes the preferred manner and form by which an individual perceives and processes information.

Module: The series of ten lessons, including the learning activities and instructional materials, designed to guide teaching in one of the two teaching modes of interest.

Teaching mode: The pattern of teacher-student interaction prescribed by the modules.

Teacher-researcher: The investigator in this study or the companion study when assuming the role of the regular classroom teacher.

## REVIEW OF LITERATURE

### Introduction

Dimensions of the effects of different modes of instruction have been explored, but the need is to consider different effects which may typically exist for learners with different personality characteristics. It is probable that different traits within learners are accompanied by different outcomes when the teaching method is varied (Berliner & Cahen, 1973). Of the possible personality traits of learners which have been identified, the present study is concerned with the cognitive style preference toward field dependence or field independence and the learning outcomes both in terms of subject matter achievement and thinking skill development.

Since the aim of this research is to explore the possible relationship of learner field-dependence-independence with two modes of instruction, the characteristics associated with these learner traits which are most likely to be evidenced in the educational setting are presented. In the final section the distinctive features of two teaching modes are described followed by assessment procedures which have been used to evaluate both product and process educational objectives.

## Cognitive Style

### Description of the construct

Individuals differ in their preferred ways of organizing what is seen, remembered, and thought about (Messick et al., 1976). The term widely used to refer to these consistently preferred patterns is cognitive style (Thornell, 1976). Although in its broadest sense cognitive style may be used to designate any typical mode of processing information (Witkin & Moore, 1974), the construct more specifically involves the characteristic ways an individual deals with surroundings which are not accounted for by ability, motivation, maturity, or creativity (Kogan, 1971). Cognitive style describes the individual differences in the form of thinking rather than the content of a thinking task (Witkin et al., 1977a).

There are not two distinct types of people within any one cognitive style (Witkin & Moore, 1974). Scores on tests of individual differences in cognitive style form a continuous distribution (Witkin, et al., 1977a). Hence cognitive style differences are differences in tendency toward a specified manner or form of cognition (Kogan, 1971).

According to Messick et al., (1976), cognitive style differs from ability in that style is bipolar while ability is present from a benchmark of zero. While the opposite of an ability is no ability, the opposite of a cluster of traits associated with one pole of a cognitive style continuum is a different cluster of traits associated with the other pole of the style continuum. The ends of a cognitive style

continuum may have implications for the likelihood of successful performance in a particular area. One's cognitive style, however, does not preclude the possibility for success in an area (Witkin et al., 1977a). That is, field independent people are more likely than field dependent people to do well in mathematics; and field dependent people are more likely to do well in art related fields than are field independent people.

In a recent publication Witkin (1976) expressed confidence that cognitive style research, such as is currently progressing under the leadership of Messick, will lead to improved definition, codification, and reliable testing of cognitive styles. The immediate goal is that of being able to map a person's cognitive pattern. This pattern, or map, would indicate preferred modes of perceptual behavior and de-emphasize the present system of classifying learners on a better to worse continuum. Thornell (1976) shared Witkin's enthusiasm for the promise of identifying the individualities of people in ways which will enhance the worth of the educational process for all.

#### Field-dependence-independence

One of the most widely studied cognitive styles is that of field dependence versus field independence (Kogan, 1971; Messick et al., 1976). This dimension sometimes called global/analytic, describes the manner in which individuals respond perceptually to complex configurations (Thornell, 1976). The early work related to the field-dependent-independent trait was conducted in the laboratory in the

late 1940s. A rod-and-frame test was one of the devices used to identify the perceptual trait which came to be called the field-dependent-independent cognitive style. In this test the subject is placed in a darkened room and a device consisting of a square frame and a rod are presented in tilted position. The task is for the subject to adjust the rod within the tilted frame until it is in what the subject perceives as an upright position (Witkin et al., 1977a). The more field-dependent person uses visual clues and tends to be influenced by the position of the frame when adjusting the rod. The more field-independent person is less influenced by the frame and uses kinesthetic clues to align the rod relative to the earth's surface. This perceptual trait is identifiable outside the laboratory using paper and pencil tests (Witkin et al., 1977a).

Identification Several instruments are available which may be used to assess the field-dependence-independence cognitive style (Thornell, 1976). Kogan (1971) summarized some of these. The paper and pencil instruments devised to categorize individuals on the basis of their perceptual characteristics direct the subject to identify a simple figure within a complex figure. People differ widely in the extent to which the surrounding visual framework dominates their perception of the simple figure. For people who are field independent the figure quickly emerges from the complex design. People at the other extreme, the field dependent, are unable to find the figure within a specified length of time. Thus the test score gives a quantitative indicator of the dominance of the field over the person's

perception of an item within the field (Kogan, 1971; Witkin et al., 1977a).

Attributes A cluster of traits are associated with the ends of the field-dependence-independence continuum. The cognitive manifestation of field dependence is that the person is guided by the organization of the field as a whole. Any part of the field is experienced as continuous with its surroundings. In other words, their perception is global. In solving problems the field-dependent person takes a long time when the solution requires that a critical element be taken out of context and placed meaningfully into a different context (Witkin & Moore, 1974). A relatively field-independent, also called analytical, person is more likely to restructure the organization of a field (Witkin, 1976).

The issue of the effects of training on a person's perceptual style is not resolved (Kogan, 1971). In 1974 Witkin and Moore noted that people are likely to be quite stable over many years in their mode of perceiving. Later Witkin et al. (1977a) pointed out that early socialization practices predispose the child to the development of a more field-dependent or field-independent style. With the exception of the Feij (1976) study, all the works reviewed regarded the field-dependence-independence trait as a stable dimension.

Genetic factors which may influence cognitive style have not been extensively researched. Witkin and Moore (1974) emphasized that the range of field-dependence-independence scores has considerable overlap between the sexes even though the mean field-dependence-



independence of males is higher than the mean of females. The current studies of Goodenough, Pizzamiglia, Ancona, and Witkin which were designed to explore the influence of genetic factors may bring more evidence to bear on this aspect of field dependence and field independence (Witkin, 1976).

#### Studies of Field-Dependence-Independence and Personality Characteristics

The literature on field-dependence-independence is voluminous though not exhaustive. A comprehensive bibliography has been compiled by Witkin, Oltman, Cox, Ehrlichman, Hamm, and Ringler (1973) with supplements by Witkin, Cox, Friedman, Hrishikeshan, and Siegel (1974, 1976). More recently reported studies and arguments related to the present research have been selected for this review.

#### Intelligence

The pattern of findings relating field independence to I.Q. is ambiguous (Kogan, 1971). However, if the distinction is maintained that cognitive style determines how an individual approaches a task, while abilities such as intelligence regulate whether a task can be mastered, the ambiguity is tolerable. Studies of the effect of the field-dependence-independence trait on other variables of interest are presented within the section dealing with the appropriate variable.

Witkin (1976) has stated that cognitive style tests may replace

intelligence tests. His argument that the former obviates the implicit value laden aspect of intelligence scores has not been the position of Kogan (1971). However, the findings reported by Quinlan and Blatt (1973) that field-independent student nurses did particularly well in surgery, while their field-dependent classmates did particularly well in psychiatry has given credence to Witkin's value argument.

Quinlan and Blatt (1972) investigated the performance of 26 student nurse volunteers as indicated by instructors' grades and reported stress. The relative field dependence or field independence of the student nurses was ascertained using the rod-and-frame test. Subjects were assigned to surgical nursing, a highly structured nonpersonal task, and to psychiatric nursing, a loosely structured interpersonal task. The groups scored similarly on the Otis I.Q. test. Field dependence correlated positively ( $r = .55, p < .05$ ) with grades in psychiatry. Although the correlation of field dependence with grades in surgery was negative, it was not significant. A positive correlation of field dependence with anxiety ( $r = .63, p < .05$ ) was found for the psychiatry group, while for the surgical group the correlation was negative but not significant. Field independence was not significantly correlated with any of these factors. It was concluded that a factual or analytical orientation may be nonfacilitating in some contexts.

### Problem-solving

Closely related to intelligence as measured by existing measures are problem-solving abilities. Field-dependent persons take a long time to solve problems which require that a critical element be taken

out of the context in which it is presented and used in a different context. Field-independent persons are less affected by the original context in which a critical element appears and solve this type of problem more rapidly than more field-dependent persons. This difference in problem-solving has not been found to be paralleled by differences in learning ability. For example, differences in field-dependence-independence scores have not been found to be related to grade point averages across colleges in universities (Witkin & Moore, 1974).

Witkin and Moore (1974) reported a study by Shapson of differences in hypothesis testing which effect successful problem-solving. Third graders were found to formulate and test hypotheses in a manner consistent with their cognitive style. The field-dependent children maintained their initial hypotheses until feedback convinced them that they were incorrect. The field-independent learners proceeded by systematically eliminating one hypothesis at a time. These differences in approach to hypothesis formulation are closely tied to the field dependents' need for aid in structuring relevant information.

### Structure

Field-independent persons are better able to organize their own strategies for coding and processing information. They are less reliant upon strategies being provided by the task or by someone else than are field dependent persons (Witkin & Moore, 1974). Several studies in the educational setting support this conclusion.

In a study of the use of video taping with student teachers,

field-dependent teachers benefited more from the viewing of a video-taped model than did field-independent teachers. The purpose of the study was to examine the effects of verbal and perceptual aspects of teacher aptitudes on the acquisition of teaching skill for two types of modeling presentations. The stratified random sample consisted of 121 subjects drawn from intern teachers enrolled in a major western university. Field-independent teachers benefited equally or more from written models. The researchers speculated that the video-taped model provided a behavioral representation which the field-dependent teacher could not generate from the written model (Koran et al., 1971).

The field-dependence-independence cognitive style was one variable hypothesized by Lezotte (1969) to be related to the learning of structured materials. Hidden Figures Test scores were obtained for separate samples of 50 boys and 50 girls varying in age from two private midwestern high schools. The reliability coefficient reported was not appropriate for the speeded test. The dependent variable was the recall, forward and backward chaining, and clustering of structured and unstructured noun lists. The factor analysis of the data was interpreted as evidence that the field dependent or field independent cognitive style was not independent of ability, and hence that variable was deleted from the study. Not surprisingly, initial ability was found to be significantly correlated with learning task success. The reported findings for cognitive style treated students as the observational unit, hence significant correlations with cognitive styles other than the one of interest in the present research were spuriously

high.

Bodine (1975) integrated questions about task structure, task setting, and mixing cognitive style in research conducted with 125 students in graduate school courses. Results approached significance in the expected directions for the field dependents and the field independents, but did not substantiate a cognitive style theory of small group behavior. It was suggested that the groups' problem-solving skills may have disguised the effects of cognitive styles in the study.

### Training

Research sufficient for establishing a relationship between training and the problem-solving and structuring skills of field dependents and field independents was not found. Feij's (1976) discussion of a study of the impulsiveness, grades, and cognitive style of undergraduate psychology students assumed that the relationship between the college curriculum selected and field independence is due to an effect of high school training on field independence (p. 798). This assumption is neither supportive of nor in direct conflict with Witkin's ongoing research which has found the trait to be relatively stable over time. Behaviors related to cognitive style are malleable. That is, while the field-dependent person may favor a spectator approach to concept attainment, Witkin (1976) has indicated that there is a possibility that such a person may be taught to evoke an hypothesis-testing approach by means as simple as providing directions for use of the latter approach.

Theories of educators whose primary research interest has not been centered on cognitive style as a classification variable are compatible with this type of investigation. Bruner's concept attainment strategies based concept attainment on repeated exposure to exemplars, examples showing the attributes of a concept, and nonexemplars, examples void of the concept's attributes. Suchman has advocated a similar method and has recognized the worth of being able to think both from the specific to the general and from the general to the specific (Joyce & Weil, 1972). Improved problem-solving ability of learners who participated in curriculum strongly influenced by Bruner's and Suchman's theories has been reported (Murphy et al., 1974). Further encouragement is offered by Bloom (1976) who stated in his latest book:

. . . what any person in the world can learn, almost all persons can learn if provided with appropriate prior and current conditions of learning. (p. 7)

### Social preferences

As is typical with other cognitive styles, the field-dependent-independent style is evident also in an individual's social behavior. Relatively field-dependent individuals tend to like people around them and to be physically close to other people. They are more interested in how other people feel, what they do, and what they say than are field-independent individuals (Witkin & Moore, 1974).

This people-oriented tendency of field dependents extends into life choices. The field-dependent person is more likely to choose vocations which involve working closely with people (Witkin & Moore, 1974).

For a younger age group evidence that field-independent individuals are more likely to enroll in high school classes in which the curriculum is more analytical and theoretical is mixed (Witkin & Moore, 1974; Feij, 1976). For example Feij (1976) reported that high school training is the antecedent condition and influences field independence test performance. However, Witkin (1973) reported that field dependent people prefer the social sciences while field independent people tend to choose more impersonal studies, such as mathematics and physical sciences.

#### Academic achievement

While the relationship of field-dependence-independence to academic achievement was a variable of interest in many of the aforementioned studies, this section presents further evidence about findings related to achievement. Two kinds of studies have been found, those in which intelligence confounds the results, and those in which a reasonable control for intelligence has been maintained. Of the former type are the Grieve and Davis (1971), and the Satterly (1976) studies which are dealt with in the next section. The Feij (1976) study reported below is also of the former type. Of the latter type are the Quinlan and Blatt (1972) study, which has already been discussed, and a recent study by Witkin et al. (1977b) reported in this section. The Witkin et al. study did control for intelligence and thus offered credible findings about the relationship of field-dependence-independence with academic achievement.

In addition to correlating field-dependence-independence scores with impulsiveness and high school training, Feij (1976) reported performance of subjects in terms of grade point averages. In the introduction to the Feij study Satterly's (1976) procedure for statistically holding intelligence constant was cited, but no mention of the statistical design employed in the study was made. It was not made clear how, or if, intelligence of the 49 psychology students in the data producing sample was related to the findings. These students were categorized as to their precollege curriculum which was either mathematics or art related. Math-trained subjects were found to have relatively high scores on the Hidden Figures Tests. Course grades in an introductory psychology course correlated with Hidden Figures Test scores only for art-trained field-independent subjects. Sex differences in the cognitive and perceptual test scores including the Hidden Figures Tests and measures of academic performance were not significant.

Evidence for the relationship of field-dependence-independence and various measures of academic performance has recently been reported by Witkin et al. (1977b). In a longitudinal study begun in 1967, the Witkin team assessed the standing of one entire college freshmen class of 1,548 students on the field-dependence-independence factor and on scholastic aptitude. Data were collected about the subject's preliminary choice of major, vocational plans, and interests. Although the sample selected for the present study is a younger-age group, the longitudinal data on academic development offered a basis



for judging the predictive value of cognitive style for both educational choices and academic achievement. Investigation of the data producing sample of 1,422 students representing nearly equal numbers of males and females evidenced low, but significant, correlations for males ( $r = .08$ ,  $\alpha < .01$ ) between cognitive style as measured on the Group Embedded Figures Test and verbal comprehension. The Embedded Figures Test and mathematical aptitude correlations were higher for males,  $r = .24$ , and for females,  $r = .38$ . Witkin et al. (1977b) pointed out the contribution of the large sample size to the significance of the former correlation and drew attention to the larger and expected correlation of mathematical ability and field independence.

On measures of overall academic achievement the Embedded Figures Test scores showed little relation to either high school or college grade point averages. The academic achievement scores, however, were related to grade point average as was expected.

The data further showed that field-dependence-independence was not related to amount of education, while higher academic achievement scores were associated with students who pursued advanced degrees. When Embedded Figures Test scores were adjusted for differences in scholastic aptitude, relationships to preferences of college major were of borderline significance for men and nonsignificant for women at college entry. For graduates, however, Embedded Figures Test scores were predictors of academic choices with high Embedded Figures Test scores being associated with science majors and lower scores being associated with education majors. This finding supports the evidence of social

preference differences of field dependents and field independents which were mentioned earlier.

On the matter of sex differences, Witkin et al. (1977b) confirmed that the range of scores on tests of field-dependence-independence within sexes was similar. This is true even though mean scores for males were slightly higher than female scores on the same measure.

Certain personality characteristics which have been associated with field-dependence-independence may predispose a student to greater achievement in either an expository or a guided discovery mode of teaching. The nature of the relationship of field dependence versus field independence to intelligence which has been described has indicated the worthiness of using the former as a dependent variable in future investigations. The nature of the characteristics of field-dependent and field-independent learners found to be related to approaches to problem-solving and to need for structure favor expository techniques for field-dependent people when the educational objective is the acquisition of knowledge. These persons, however, may prefer the social context of a guided discovery approach and might be expected to benefit from methods which encourage development of problem-solving and structuring skills in an interpersonal approach to subject matter. Successful performance has been shown to be possible for both field-dependent and field-independent people depending upon the task.

Problems Associated with Cognitive Style Research  
Using Intact Classes

Selected studies of the characteristics of field-dependent and field-independent persons have already been presented. Following are some of the problems which relate more specifically to carrying out cognitive style research in the classroom.

Trait has been the word used by Berliner and Cahen (1973) to indicate individual difference variables which may interact with instructional treatments. They proposed that studies be designed to investigate the regression lines formed by traits and educational outcomes for different instructional treatments. The interpretation of the results of such statistical treatments has not been without controversy. Bracht and Glass (1968) held that only disordinal interactions have significance for the social sciences. Berliner and Cahen (1973), however, believe ordinal interactions also offer advantages for educational research. The question to be resolved has been one of external validity for the ordinal, or less conservative approach. References for the use of the ordinal interpretation have been presented by Berliner and Cahen (1973).

Tobias and Ingber (1976) discussed factors which limit the findings in treatment interaction studies. They noted that studies in which alternative instructional treatments differ in ways which do not engage the different abilities of interest are unlikely to reflect interactions with the different abilities. In addition, results of instructional treatments designed to draw on different abilities may be limited since

alternate abilities may be drawn upon and hence limit the occurrence of an interaction. Further he has questioned the extent to which the content area influences the findings for replications in different content areas. Tobias and Ingber have also recognized the problems of developing treatments which can be employed outside the laboratory for extended periods of time.

Another methodological problem which was noticed in the literature was the failure of researchers to clearly differentiate between preexisting conditions and findings. For example, Grieve and Davis (1971) assigned learners on the basis of field dependence and field independence to achieve a balance of global and analytical males and females in a study of ninth-graders' performance in geography taught by two methods of instruction. While the authors stated that there was no reason to believe that the classrooms differed in ability, the data were analyzed by individuals rather than classrooms, and no evidence was presented to indicate the initial ability of any of the categories of individuals. The overall effect of method was not significant. Learning deficits for extreme global males in knowledge acquisition when the method was expository were found in a secondary analysis of the data. This finding did not hold for the comparable female group. It was further reported that extreme field-independent subjects, those who scored above 22 on the Hidden Figures Test, were better able to apply knowledge in new situations regardless of the instructional method. No evidence was presented which precluded the possibility that this tendency existed prior to the treatment.

A further problem is the lack of a rationale for grouping learners on the cognitive trait within classrooms. Bodine (1975) investigated cognitive style, task structure, and task setting on student performance in field-dependent, field-independent, and mixed small groups. The respective group means on the Hidden Figures Test based on 40 subjects each were 5.20, 18.25, and 11.17. The mixed groups achieved the higher performance on group tasks, followed by the field-dependent groups, although the latter was not significant. It was theorized that the maintenance skills of the group members may have influenced the group interaction more than the cognitive styles of the members. Bodine recommended that the effects of different proportions of field-dependent and field-independent subjects within groups be examined.

Presentation of examples of the problems associated with accepting the findings in reported cognitive style studies has been limited since the main thrust of the present study is not a comparison of statistical designs. However, brief mention of Satterly's (1976) report of a substantial overlap between field independence and intelligence for 201 boys is made in order to make note of Humphreys and Parsons' (1977) critique of the analysis. The controversy dealt with the technique of partialing out the effects of fallible measures such as intelligence as was done in the Satterly (1976) study. Humphreys and Parsons' (1977) argument for an appropriate factor loading would necessitate different interpretations of the data. Satterly's findings have intentionally not been included in this review, since the study was mentioned only to serve as a caution against techniques which might be considered for

use with data where initial ability differences in the sample groups were a problem.

The variety of research designs and statistical procedures evidenced in studies of cognitive style as it relates to education has made replications and comparisons of findings difficult if not impossible. Recognizing these problems, Berliner and Cahen (1973) have cautioned investigators to display data and avoid conclusions which do not stand up under replication.

### Thinking Skill Development

#### Methods

An important objective of education has been the development of critical thinking (Taba & Elzey, 1964). Strategies to attain this objective have been proposed by many educators including Bruner et al. (1967), Suchman (1962), Taba (1966), and Thelen (1960). These strategies share an emphasis on the skills of thinking, and active student participation or discovery. Evaluation of such instruction would then logically be in terms of the objective, to develop thinking.

Didactic teaching on the other hand is subject matter oriented and appropriately evaluated in terms of the subject matter objectives (Martinez-Brawley, 1977). Other teaching modes have been defined, but the present study is limited to the possible differences in outcomes of the student oriented guided discovery approach and the more teacher centered, expository approach.

Research comparing expository and discovery methods has yielded

conflicting results. In general short-term retention has been associated with expository methods while discovery methods have benefits in long-term retention or transfer. Because of these trends, Scott and Frayer (1970) have recommended the use of more than one dependent measure in discovery research.

The assessment of two basically different outcomes, achievement in terms of content and process are presented. The assessment of subject matter achievement, frequently called content assessment, is discussed first followed by the assessment of mastery of the thinking skills identified by inquiry process objectives.

#### Subject matter achievement assessment

In order to determine differences in kinds of learner outcomes, classification systems have been developed. One of these, Bloom's (1956) cognitive domain taxonomy, has been widely used by test developers to categorize learning outcomes. Bloom's system and selected research employing his system or other cognitive classifications of achievement which are closely related to the present research are herein reported.

In the early 1950s a team of educators headed by Benjamin Bloom developed what has become a popular scheme for classifying behaviors (TenBrink, 1974). The scheme was entitled the Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook I: Cognitive Domain (Bloom, 1956). The purpose of the publication was to classify educational goals since educational objectives had frequently

been the starting point for educational research. The intended behaviors described within the taxonomy which are of specific interest in the present study have been called knowledge and application. These levels of cognitive behavior were described by Bloom.

Knowledge . . . involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. Although some alteration of the material may be required, this is a relatively minor part of the task. (p. 201)

Application [involves] The use of abstractions in particular and concrete situations. The abstractions may be in the form of general ideas, rules of procedures, or generalized methods. The abstractions may also be technical principles, ideas, and theories which must be remembered and applied. (p. 205)

In discussing testing for these two levels, Bloom has pointed out that testing for knowledge behaviors has been more fully developed than for other cognitive levels. Relatively few items may be used to adequately test a rather large universe of knowledge.

On the other hand the reason for teaching knowledge, so that students successfully meet situations not encountered in the learning process, has presented more complex testing problems. Bloom has presented factors to be routinely taken into consideration when testing for the application level of student cognitive behavior. Among these factors are the need for situations which are truly new to all students including those who may have read beyond the classroom assignments. Also a distinction to be maintained is assurance that what is tested



is the application of specific principles rather than general problem-solving ability. The suggestion was made that items be used with students of the same general ability who had not had the instruction in order to identify those items which most appropriately indicate application of the intended principles. Further it was cautioned that both an adequate sampling of situations be included, and that care be taken to differentiate among reasons students miss applications. The inability to comprehend could be identified by testing the students' understanding of the situation before presenting the application questions (Bloom, 1956).

Correlations between test items designed to measure knowledge and application of the knowledge in a case study approach were computed in a study reported by Horrocks (1946). To three groups of college students enrolled in courses related to adolescent behavior, educational psychology, and mental hygiene, a test of facts and principles was administered. The reliability coefficient obtained by the split-half method was .91. The length of the test was not specified, nor were difficulty and discrimination indices. The validity of the test was based upon its reliability, internal consistency, coverage, construction, and keying. This test was used as the criterion measure and correlated with scores on three case study tests each of which was administered to 100 of the total 300 students which comprised the sample. Each case study test was divided into three parts. Each part included opportunity for the students to diagnose difficulties and select appropriate remedial procedures. A weighted composite of expert opinion

made up the key on which the case study tests were scored. The split-half reliability coefficients for the three studies were .73, .77, and .79. Test validity was indicated by construction and coverage, expert scoring, item consistency, reliability, and utility.

In no instance were correlations of the criterion measure with a case study test as high as .50. Obviously while the higher cognitive ability tests measured some aspects in common with the knowledge test, the tests were also measuring different aspects. The Horrocks (1946) study made plain the inappropriateness of knowledge tests as predictors of the ability to apply the knowledge. It could further be inferred from Horrocks' work, which preceded the Bloom (1956) scheme and was cited by the latter, that educational outcomes exceed those which can be measured by knowledge of facts and principles tests.

The work of Horrocks (1946) and Bloom (1956) has been followed by studies which have contributed in different ways to means of assessing learning outcomes beyond the knowledge of facts and principles. Studies presented in this review were selected to represent options which could be considered in the development of the achievement test for the present study.

The format of Bloom's taxonomy guided the development of achievement tests constructed by Nelson and Jacoby (1968) to measure progress toward cognitive objectives for two occupational home economics courses in schools of a major eastern city. Both tests were designed to measure the recall, understanding, and application levels of the appropriate subject matter objectives. Kuder-Richardson reliability

coefficients of .75 and .71 were accepted for the tests. While the discrimination indices for the majority of the items were acceptable, a few nondiscriminating items were included in both tests to meet the table of specifications for the tests.

Establishment of the quality of the tests developed for the Nelson and Jacoby (1968) study was precisely outlined. A literature review, interviews, and the table of specifications based on the cognitive objective of the courses substantiated the content validity of the instruments. The adequacy of the items was judged by a panel of experts. The resulting instruments were 64 and 51 items in length and were used to establish pre, post test change scores.

Kizer (1973) in a correlational study of classroom interaction, cognitive behavior sequences, and other selected variables with student learning, developed and categorized items using a classification system not unlike Bloom's which was devised by Brun (1970) for purposes of coding classroom interaction. Some problems were reported by Kizer (1973) in gaining consensus on the coding of items, particularly in the recall category. This difficulty might have been predicted since the Brun definitions were descriptive of verbal behavior and more limiting than those of the Bloom (1956) works. Further the classifications were quite close in terms of the cognitive behaviors described, and hence offered great opportunity for disagreement among the judges.

The procedure followed by Kizer (1973) involved building items to supplement an existing test of child development subject matter and extensive conferences with judges for the purposes of establishing the

cognitive level measured by each question. The test included multiple choice items for measuring lower cognitive levels and short answer items for measuring higher cognitive levels. Reliability coefficients based upon a total of 13 classrooms of .48 for class groups and .69 for comparable groups were judged adequate for the purposes of the study.

In addition to the test development procedures used by Kiser (1973), of interest to the present study was the recommendation made based upon a failure of the data to support the hypothesis that a relationship existed between patterns of cognitive behaviors and learning. The suggestion was that more variation in student cognitive processes among classrooms be planned for in future studies.

A slightly different reference was established as the basis for categorizing learning outcomes in a comparison of discovery and expository programmed instruction using a sample of 389 ninth graders. In this study, Tanner (1968) controlled for amount of learner activity, medium of instruction, interteacher variability, selection, and history. No significant differences for the discovery learning group were found. He recommended replication of the study since there was a trend in the intercorrelations indicating a possible interaction of treatment, interest, and success on cognitive measures.

Tanner (1968) measured cognitive success on three scales: comprehension, lateral, and vertical transfer. The comprehension measure was designed to measure what had been learned from programmed instructional materials. For the 25-item test the odd-even reliability in a pilot

test of 56 subjects was .76 with a test-retest correlation of .78. The lateral transfer items demanded new application both of concepts and principles. The vertical transfer measure required the subject to combine two out of three principles to answer the items. The reliability of the latter two tests was .81 and .89 respectively. The difficulty for the devices were: comprehension, .35; lateral transfer, .29; and vertical transfer, .42. The subject matter of the instructional treatment was arrangeable into hierarchies of concepts, principles and higher order principles.

Physical science curriculum was designed specifically for this study so that manipulation of the treatments was free of as many extraneous variables as possible. The distinction between the treatments was the order of presentation. In the expository treatment principles were made explicit to the students, while in the discovery treatment the student inferred the principle, if the principle was learned at all.

Physical science principles were the basis for the test development. Each principle was represented equally for the lever, inclined plane, and wheel-and-axle problems. The lateral transfer items required transfer to new machines such as pulleys, screws, and wedges. The vertical transfer items required the student to combine two or three principles from the principles programed in the instructional materials. The item format included various length multiple option items, short answer, and matching types. Interpretation of graphic representations seemed essential to most of the items.

While the Tanner (1968) study was apparently free of the shortcomings of treatments yielding similar learner classroom behavior, a problem noted earlier in the Kizer (1973) study, the format of the test questions may have confounded Tanner's results. As was mentioned, the items relied heavily upon graphic representation. The ability of students to deal with such abstractions could have been suspected to influence the test scores of learners in both treatment groups, and thus may have disguised real differences in learning.

The achievement criteria used in a study designed to test the hypothesis that concept method procedures produce greater acquisition, transfer, and retention of knowledge than expository method procedures were tests of concept acquisition and concept retention (Hoover & Cauble, 1974). The N on which split-half reliability coefficients of .80 for the former and .85 for the latter tests were based was not reported, nor was the number of items reported for either multiple choice test. The establishment of construct validity was not mentioned, and there was no explanation for the selection of items purported to measure concept acquisition from a device referred to as "Application of Principles Test I". As noted earlier there is no reason to believe that knowledge acquisition can be measured appropriately by application of principles.

The data analysis indicated 1 and 653 degrees of freedom were used to interpret data collected in 5 family relations classes. The authors mentioned several possible factors which could have contributed to a lack of significant results, including the use of the same text

materials for both treatment groups. The authors felt further investigation warranted (Hoover & Cauble, 1974). Certainly many modifications of the methodology, including establishment of appropriate construct test validity, would be necessary before significant F values could be expected.

The Hoover and Cauble (1974) study offered to the present investigation only the stated achievement criteria, classification of acquisition and transfer of knowledge. These classifications, which were not operationally defined, would seem compatible with Bloom's (1956) taxonomy offering further evidence of the popularity of the Bloom scheme.

Both the purpose of a study by Hughes (1968) and the construction of the assessment devices were dependent upon the classification of cognitive skills developed by Bloom (1956). The sample consisted of 32 classes and involved 604 eleventh and twelfth graders enrolled in 26 schools in districts of various sizes throughout the state of New York. The specific objectives of the study dealt with a curriculum unit, its practicality, usefulness, and relation to affective and cognitive learning outcomes, the relationship of the affective and cognitive domains, and validation of the hierarchy presented by Bloom. Of most importance to the present study were the procedures followed in the development of the assessment devices.

Six principles taught in a unit on preparation for the dual role of homemaker, wage earner were the content base for achievement items developed in the Hughes (1968) study. For each principle, items were written at each of the seven steps of the first three levels of Bloom's

taxonomy. Through the use of a five-member panel judging procedure, the items were validated as to level and representation of a single idea. Final item choice was based upon item statistics as well as taxonomy-level validity. Pilot testing,  $N = 100$ , of the items further contributed to the integrity of the final test. A multiple choice format was determined to be the most appropriate means of assessing the educational outcomes of interest. The 42-item achievement test used as the post test yielded Kuder-Richardson-20 reliability of .78. The mean difficulty was 52 with a range of 46 to 56, the average test score being 27.5. The discrimination mean was .36 with a range of .30 to .45.

A most carefully and precisely defined method for the development of achievement items at all levels of Bloom's (1956) taxonomy was presented by Smith (1968). The author prefaced his offering by requesting it be viewed as the basis for discussion, and throughout the article he pointed out inherent shortcomings of the use of a multiple choice format for higher levels of the taxonomy.

A novelty of his approach was presenting a communication with each item set. Each communication was composed of a few paragraphs of intentionally easy reading, and included the two or more concepts with their definitions which made up a physical science principle, along with a set of hypothetical experimental data which when encoded enabled the student to extrapolate the principle. The communication was used to hold nearly constant familiarity with new situations to be used in application items.



The seven or eight, multiple choice items which comprised each item set were exactly written to separately test 1) knowledge of a term, 2) knowledge of a principle, 3) recognition of the principle in a reordered form or interpretation, 4) ability to predict outcomes by using different combinations of the variables in the same situation, or extrapolation, 5) selection of the principle appropriate to the characteristics of a new situation, or application, 6) analysis, 7) synthesis, and 8) evaluation. To summarize Smith's remarks dealing with the complexities and difficulties inherent in the development of the three highest order questions would do disservice to his presentation. Since the treatise involved theoretical controversy related to Bloom's hierarchy, which is beyond the scope of this review, suffice it to say that Smith recognized difficulties which accompany testing the higher levels, especially when the item format is multiple choice.

The reproducibility coefficients obtained using Smith's (1968) standards for item sets ranged from .87 to .93. It was pointed out that these coefficients were spuriously high due to the extreme variation in difficulty inherent in the cumulative and hierarchical structure of the taxonomy on which the item sets were based. Scaleability coefficients obtained ranged from .56 to .72 and were judged acceptable.

While the thrust of Smith's (1968) work was to gain insights upon which to base recommendations for improved assessment of cognitive skills, it has direct application to basic item writing. It would seem that an item writer could become sufficiently familiar with principles taught to eliminate the communication statements which were vital to

Smith's items. Given learning activities which were planned to teach principles and their root concepts, quality items could be written following Smith's general approach to assessing cognitive achievement.

Smith (1968) addressed the chief disadvantage of the use of communication statements which is that one cannot be sure if the student recalls the facts and principles or searches them out of the communication in order to answer the knowledge level questions. It would seem to this writer from inspection of the example item set that what may have been measured was at least in part the learner's thinking process skills since all information needed to answer each question was contained in either the communication statements or in the preceding questions of the item set. This observation is in no way a criticism of Smith's work in terms of his purposes. Yet, if learning can be measured apart from what is taught by the classroom teacher, as Smith had apparently done, then an objective of education which logically could be assessed is the improvement of thinking skills. This type of assessment was the undertaking of Murphy et al. (1974) and is discussed in the next section of this review.

#### Inquiry assessment

An evaluation instrument for assessing the educational goal of improving thinking skills was developed by Murphy et al. (1974). Although the device was designed for use in a consumer education curriculum project, the content was intentionally chosen so that its application could be subject matter free. In order to show the applicability

of the Inquiry Process Assessment Items to the purpose of the present study, the process objectives which it measures, a summary of the philosophy underlying its development, and the manner in which it was developed follows.

The thinking skills identified by Murphy et al. (1974) formed what the authors called the Inquiry Process. The skills of the process were established as those mastered by persons who have met the need to know via successful inquiry. The specific objectives which comprise the Inquiry Process follow:

. . . the learner will demonstrate use of the inquiry process at a level of mastery by:

- 1) recognizing a problem which defines a purpose for inquiry and states clear and specific questions that guide the inquirer and limit the scope of the research.
- 2) considering tentative solutions based on hypotheses derived from the learner's past experience, knowledge, and analysis of available data.
- 3) clarifying terms and concepts, giving each a definite meaning so that relevant sources will be used to investigate the hypothesis.
- 4) collecting data and evaluating data sources for accuracy, credibility, and relationship to the hypothesis.
- 5) analyzing data to test the hypothesis and develop a conclusion.
- 6) applying a conclusion to new situations. (Murphy et al., 1974, p. 39)

In order to assess mastery of the Inquiry Process objectives, a transition was made from considering subject matter to be the content

to recognizing thinking skills as the content. The criterion-referenced Inquiry Process Assessment Items (Murphy et al., 1974) were developed to identify mastery of thinking skills.

Frequently the distinction between norm-referenced and criterion-referenced tests have been restricted to the interpretation of the results. However, the developers of the inquiry evaluation device adopted a mastery philosophy prior to the identification of the learning objectives. Therefore, the judgment by experts of the content and construct validity involved answering two questions: 1) do the objectives and the items identify accurately the behavior specified in the outside criterion?, and 2) do the items measure the stated learning objectives? The outside criterion, a continuum of consumer behavior, does not detract from the usefulness of the test for the present research since the continuum itself relies on a belief that the improvement of the individual's behavior can be achieved by improvement of that individual's thinking process.

The Inquiry Process Assessment Items is an objective device which utilized multiple choice, modified matching, and short-answer formats. A scoring system and a code were provided to facilitate the construction of tests for assessing particular objectives.

Item difficulty and item discrimination of the sort used in the development of norm-referenced tests was not deemed appropriate for the mastery test. Reading difficulty was measured using the Flesch formula and found to require on the average a ninth-grade reading level. Test, retest reliability and consistency within subscales

were established prior to the use of the items in a national field test of curriculum materials. The reliability coefficient obtained for the test was above .80. That significant  $t$  values ( $\alpha < .05$ ) were obtained for the high and low class mean change scores of the over 5000 participants in the learnings designed to teach the process objectives may be interpreted as further evidence of the construct validity in terms of the process objectives.

### Summary

Reviewed for this research were studies and articles emanating from psychology and education. The construct labeled the field-dependent-independent cognitive style was described in terms of its documented and theorized attributes most directly relate to the present investigation. Selected research dealing with personality characteristics which have implications for educational planning were presented. Studies and cautions aimed at increasing the reproducibility of cognitive style research findings were handled within a separate section to focus attention on methodological problems.

Since the development of a subject matter achievement device was an important part of this research, the test development procedures discussed in studies and research which included the development of instruments to assess educational outcomes were reported. The assessment of two kinds of educational outcomes, attainment of content objectives and mastery of process objectives were addressed.

As mentioned before, comparisons of expository and guided discovery

modes of teaching have yielded conflicting results. Likewise attempts to determine modes of instruction which benefit specific cognitive styles have been inconclusive. By identifying the field-dependence-independence of learners in classrooms taught common subject matter in either an expository or a guided discovery instructional mode, the present study is an attempt to identify differences on two dependent measures, subject matter achievement and mastery of inquiry process skills.

## METHODOLOGY

This study was concerned with the methodology and procedures related to the gathering and processing of data, rather than those related to the treatments per se. The data collected were a measure of field-dependence-independence, the student background information, and the measures of achievement for subject matter and process objectives.

The treatment was one of two teaching modes. The teaching modes were expository and guided discovery as described by Stout (1977) and discussed briefly in this chapter. The patterns of instruction followed were presented in two equally attractive energy management modules prepared by Stout. Each module contained a series of 10 lessons.

### Statement of the Problem

The purpose of the study was to compare expository and guided discovery teaching modes in terms of subject matter achievement and mastery of inquiry skills for learners who differed on a measure of field-dependence-independence. The primary objectives were:

1. To determine if classrooms of learners which were taught in an expository mode differed from those taught in a guided discovery mode on measures of inquiry process or subject matter achievement, and
2. To identify a possible trait treatment interaction of the learners' cognitive style with an expository or guided discovery teaching mode.

### Hypotheses

- 1a. Mastery of inquiry process skills is the same whether the teaching mode is expository or guided discovery.
- 1b. Mastery of inquiry process skills does not depend on performance on the Hidden Figures Test.
- 1c. Mastery of inquiry process skills does not depend on past academic achievement as measured on the Iowa Test of Basic Skills.
  
- 2a. Subject matter achievement is the same whether the teaching mode is expository or guided discovery.
- 2b. Subject matter achievement does not depend on performance on the Hidden Figures Test.
- 2c. Subject matter achievement does not depend on academic achievement as measured on the Iowa Test of Basic Skills.
  
- 3a. Mastery of inquiry process skills is the same for relatively field-dependent and field-independent learners whether the teaching mode is expository or guided discovery.
- 3b. Subject matter achievement is the same for relatively field-dependent and field-independent learners whether the teaching mode is expository or guided discovery.

### Assumptions

- 1. The teacher-researcher achieved the classroom interaction prescribed by the teaching mode of the assigned module.
- 2. The subject matter content was relatively new to the learners.



3. Learning differences both in the achievement of subject matter objectives and development of inquiry skills were observable within a two-week period.
4. Students differing on the field-dependence-independence trait were randomly assigned to classrooms in the regular scheduling procedures used in the participating schools.

#### Description of the Sample

Home economics classes within a 60-mile radius of Ames, Iowa, were reviewed for participating in the study. Classes were identified after perusing records of the Iowa State Department of Public Instruction for the 1974-75 school year and after consultation with the state home economics consultants. The criteria for selecting the final sample were: class sizes of less than 30 students, curriculum offerings in housing or comprehensive home economics, and potential for enrollment of both sexes.

Cooperation of the appropriate school administrators and classroom teachers was solicited and obtained for participation in the study. The classroom teacher and the appropriate school officials for each school were visited by the researcher. All teachers selected their spring classes which most appropriately would benefit from an energy management unit. A purposive sample of twelve classrooms resulted. Seven schools participated in the study.

The composition of the intact classes was controlled by the regular school scheduling procedures. On the basis of the data obtained there

was no reason to believe that the students in the various schools and classrooms differed collectively in ability. Similarly, the field-dependence-independence trait test scores were distributed across the classrooms. The sex composition of the classes did differ, but this was neither within the control of the researcher nor of central interest in this study.

The teacher-researcher observed no differences in the range of the interests of the students in various classrooms with respect to the energy management subject matter. The home economics programs from which the sample classes were taken were broad in scope and met the criteria for comprehensive home economics offerings. Students entered the energy management units after units in adult living, foods and nutrition, clothing and textiles, child development, and housing. Of the 170 students for whom complete background information was available from the school records, 136 were females, 34 were males, 26 were sophomores, 76 were juniors, and 68 were seniors.

The number of minutes the classes were scheduled to meet varied from school to school and within schools. Since lessons were designed for ten classroom sessions, the regular classroom teachers were asked to plan that their learners participate for ten days plus a testing day, or the approximate equivalent in schools using innovative class scheduling procedures (see Table 1).

Table 1. Enrollment and minutes classes met for instruction

School	Class	Enrollment	Minutes
1	1	18	315
2	1	11	550
3	1	8	405
3	2	15	405
4	1	15	480
4	2	12	500
5	1	12	520
5	2	26	520
6	1	7	320
7	1	16	500
7	2	21	500
7	3	15	500
Totals = 7	12	177	

### Instrumentation

Four kinds of data about the learners were obtained. The total score on the Hidden Figures Test—CF-1 was used as an index of the learner's cognitive style of field dependence versus field independence. The composite scores on the Iowa Test of Educational Development provided a control for the achievement pattern of the learners. The development of thinking skills was measured with the Inquiry Process Assessment Items. A subject matter achievement device was constructed to yield scores for two levels of achievement and a total achievement

score. A discussion of each instrument as used in the present study follows.

#### Hidden Figures Test—CF-1

Recent studies have employed the Hidden Figures Test—CF-1 (Educational Testing Service, 1962) as an index of learners' cognitive style of field dependence versus field independence. In the Koran, Snow, and McDonald's (1971) comparison of two educational methods used with teachers, the Hidden Figures Test yielded significant interactions with the variables of interest. Bodine (1975) found the device useful for purposes of categorizing college students in a study of group dynamics. The CF-1 version of the Hidden Figures Test was considered for use in the present study because it had been used in similar studies, was designed for group administration, and was available at a nominal cost.

A pilot study was conducted with 108 students enrolled in four vocational programs at a midwestern community college to explore the usefulness of the device in the present study. The following positive aspects of the device were identified in that pilot study. Students found the device nonthreatening. The administration procedures for the test were simple enough for the device to be useful for data collection for this study. The device was readily scorable using optic scanning procedures. Significant F values were not found for any of the vocational areas nor for sex of the students.

The CF-1 version of the Hidden Figures Test consists of two equivalent 16-item, timed sections. The instructions directed the respondents

to identify one of five simple figures within blocks of geometric patterns. A sample problem with the solution is shown in Figure 1.

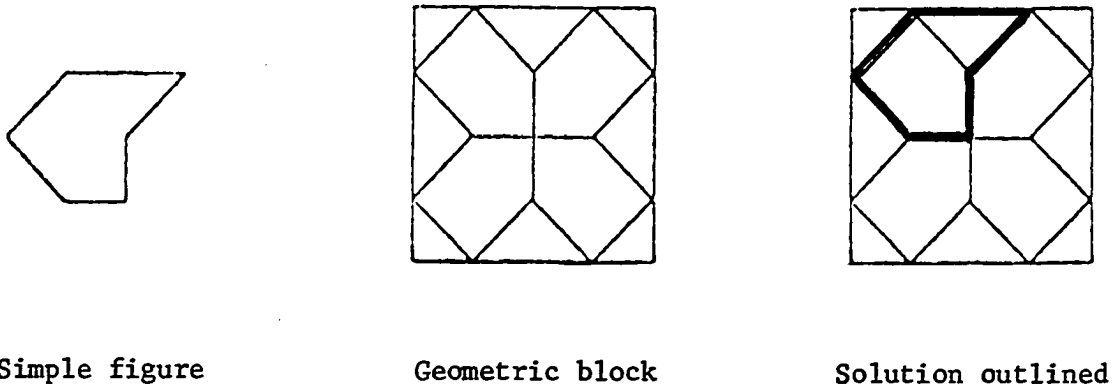


Figure 1. Sample Hidden Figures item

A subject's score is the total number of correct responses marked within two 10-minute intervals.

The Hidden Figures Test is printed in black straight lines which offered greater usability than colored versions which cannot be adequately copied. It had the further advantage of being designed for responding on answer sheets which could be mechanically scored.

The Educational Testing Service was contacted and a licensing agreement issued to the researcher. The agreement was signed, and fees were paid so that the instrument could be reproduced locally (see Appendix A). In accordance with the March 11, 1977 letter from Educational Testing Service (see Appendix B), no copy of the instrument is bound into this thesis.

Since the Hidden Figures Test is a two-part timed test, the

reliability was computed in accordance with procedures for speeded tests. The test was split in half time wise rather than item wise as mentioned by Thorndike (1971, p. 416). Using the Spearman-Brown Prophecy formula the expected reliability of the total test was .74. The maximum possible score was 32. The range of scores was 0 to 25 with a mean score of 9 and a standard deviation of 5.14.

#### Control for achievement

The administrators of the schools in the participating sample discussed with the researcher the potential for obtaining an outside measure of the learner's achievement patterns. It was determined that grade point averages and scores on the Iowa Test of Educational Development were obtainable in all schools. It was decided that the composite score from the Iowa tests was more useful than the grade point averages since the former was reported in percentiles based on Iowa norms, while the latter was based upon the standards of the individual schools. The data requested and associated with the identification number of each student were the composite percentile on the Iowa Test of Educational Development, the grade level, and the sex. The requests for the information about the students complied with the policy of the Iowa Department of Public Instruction (1976) (see Appendix C).

#### Inquiry Process Assessment Items

The Inquiry Process Assessment Items (Murphy et al., 1974) were developed to identify mastery of thinking competencies. A test was constructed from these items to measure possible differences in the

development of thinking skills between the treatment groups.

The reliability of the inquiry device when it was used in a national curriculum project was .80. Content and construct validity were obtained through judging procedures appropriate for criterion referenced tests.

The length of the inquiry process test (see Appendix D) was restricted to 25 items in order to accommodate available testing time. In a trial of the shortened test it was determined that a majority of 58 learners enrolled in two high school home economics classes could complete the test within 20 minutes. The items were selected to fill the following test blueprint in accordance with the developers' suggestion, ". . . choose to administer all or some of the assessment items depending upon the age, interest, and abilities of your learners and your teaching situations" (Murphy et al., 1974, p. 83).

Objectives	Item numbers (see Appendix D)
1) recognizing a problem	1, 2, 3, 5, 6, 8
2) considering tentative solutions	7, 9, 10, 11
3) clarifying terms	12, 13, 14, 15, 16, 17, 18, 19
4) collecting data	4, 20, 21, 22, 23
5) analyzing data	24, 25

Since the test was comparatively short, no items were discarded based upon the interitem correlations obtained. The reliability coefficient for the 25-item test, based upon 177 answer sheets, was .71.

### Energy Management Test

An objective referenced test was developed to assess the learning of the energy management modules' subject matter. The objectives, developed by Stout (1977) for the modules, were categorized into groups based upon the Taxonomy of Educational Objectives Handbook I: Cognitive Domain (Bloom, 1956). Objectives which were within the knowledge level and those which were within the application level of the cognitive domain served as the references for the development of the test.

Information which would contribute to the item writing was collected from high school students and the mass media. Students participating in a pilot test of the modules were asked to respond to open ended questions about energy. These questions had the general form: "What do you remember. . . ?" "What would be important to you in the future. . . ?" or "What affects your life. . . ?" The student comments, a collection of articles and cartoons, notes from television presentations, radio programs, and energy conferences, as well as the modules, provided the base for the item development.

Sixty-three, four-option multiple choice items were written. Of these at least two were referenced to each level of objective for each of ten lessons. These items comprised a trial test and were screened for inclusion in the final test.

Each question was developed to measure the attainment of a specific objective of the modules. The content validity was further established by reviewing each item with the curriculum writer. A subject matter



specialist as well as the curriculum writer judged as accurate the factual base of each question.

A panel approach was also used to judge the inferred cognitive level measured by each item. Two judges, an evaluation expert who was familiar with the modules and the curriculum writer, met with the test writer and verified the level of each item based upon the following criteria set forth in a letter to the judges (see Appendix E).

- 1) The knowledge level questions will demand recall involving little more than bringing to mind the appropriate material.
- 2) To be judged application answering the question must necessitate more than simply understanding. These questions should require that the student deal with abstractions or apply technical principles, ideas, or theories.

The items were also screened for technical errors. An outside reader and a computer program, Multiple Choice Test Analyzer, (Hausafus, ca. 1977) identified technical difficulties which were corrected for items included in the final test.

The trial device was administered to 37 high school students in two home economics classes. Of the original 63 items, eight had been disqualified by the judges before the trial. The remaining 55 items were scored and examined in two ways. Fifteen of the students had received some instruction based upon the modules during a pilot study. This group was designated the "yes" group for test analysis. The remaining 22 students had not received instruction based upon the modules. This group was designated the "no" group. All tests were scored and a

reliability coefficient of .80 was obtained for the "yes" group on the total test. For this group the reliability on the 26 knowledge items was .77, and for the 29 application items the reliability was .44.

Student data on the items which survived the content and level judging procedures were inspected. Items for which there was a spread of answers among the distracters were selected for inspection based upon item difficulty. Only items on which the "yes" group scored higher than the "no" group and on which the "no" group scored less than 62 percent, an arbitrary cutoff point, were considered for the final test. Assessment of the test quality was not as rigorous as desired. No large group of appropriate age which could have been expected to have the required knowledge base was available.

The table of specifications (see Table 2) was filled so that there was one knowledge objective referenced item for each lesson plus one easy item to be used as the first question on the final test. Where two application level objective referenced items appeared to be of about equal quality, both items were placed on the final test. This was an attempt to lengthen this subscale which was suspected to continue to produce low reliability coefficients.

A copy of the Energy Management Test is included in Appendix F. Correct responses are indicated on an annotated blueprint for the test (see Appendix G).

To determine scoring procedures for the Energy Management Test an interitem correlation matrix for the 26 items was generated and inspected. The interitem correlations ranged from  $-.15$  to  $+.30$  with

Table 2. Table of specifications for the Energy Management Test

Lesson		Knowledge level items	Application level items
Number	Topic		
1	History of energy use in America	1	1
2	Problems and physical laws	1	1
3	Conservation alternatives	1	2
4	Home consumption	1	2
5	Energy efficiency	2	2
6	Nature and housing	1	1
7	Selecting housing	1	1
8	Controlling heat flow	1	2
9	Acceptability of sources	1	1
9-10	Solar heating	<u>1</u>	<u>2</u>
	Totals	11	15
Test length = 26 items			

$\bar{r} = .065$ . For each item the average interitem correlation ( $r_{ij}$ ) with the other  $n-1$  items was computed (see Table 3). Both because each item was developed to measure a specific objective and because the final test was short, standards for acceptable average interitem correlations were reduced to allow maintenance of all items which exhibited even small positive average interitem correlations. One item evidenced a slightly negative average correlation with the other items. This item was

Table 3. Interitem correlations, total test correlations and difficulty for Energy Management Test

Item number	$r_{ij}$	$r_{it}$	Difficulty level
1	.13	.52	.71
2	.07	.34	.75
3	.11	.47	.65
4	.13	.51	.44
5	.11	.47	.54
6	.14	.54	.63
7	.03	.22	.28
8	.07	.34	.40
9	.05	.25	.83
10	.06	.27	.20
11	.04	.25	.30
12	.07	.35	.69
13	.00	.12	.33
14	.03	.23	.33
15	.07	.31	.76
16	.06	.31	.62
17	.10	.43	.40
18	.01	.16	.56
19	.04	.25	.56
20	.02	.19	.63
21	.05	.28	.34
22	.04	.26	.39
23	.04	.26	.45
24	.11	.43	.74
25	.08	.37	.74
26	.03	.20	.34

inspected for technical difficulties and none was found. Since it evidenced a slightly positive correlation with the other items in its subscale, it was included in the total scoring of the test. Inspection of the interitem correlation matrix indicated that true subscales did not exist in the test.

To represent the discrimination index of each item total correlations ( $r_{it}$ ) were also generated. These values are shown along with the interitem correlations in Table 3. The relationship between the two types of correlations is computed approximately by the conversion factor formula,  $\frac{1}{\sqrt{\bar{r}}}$ , where  $\bar{r}$  is the mean of the interitem correlations. The numeric value of the conversion factor was 3.9.

The mean score for the 26 items was 13.61 or 52% based on the 177 students. For the 11 knowledge level items the average score was 6.9 or 63%. For the 15 application level questions the average score was 6.71 or 45%. The mean difficulty of each item is shown in Table 3.

Reliability of the test as determined by the Spearman-Brown procedure was .64 for 26 items based upon 177 student answer sheets. Several factors influenced the reliability of the Energy Management Test. The shortness of the test contributed to its low reliability, but it seemed more reasonable to report the coefficient for the test of 26 items given rather than extrapolate to a hypothetical, longer version such as 52 items. Further, the reliability was adversely affected by the application items which were slightly more difficult than the test as a whole. For the experimental design, which used group means, the

reliability of .64 was adequate for group differentiation and well above the .50 which Borg and Gall (1971, p. 459) have stated is adequate for crude group predictions.

#### Treatment

Two modes of teaching, expository and guided discovery, were the treatment variable. The modes were implemented by following the modules prepared in a companion study. The following conditions were met by the modules.

1. The content of the modules was relatively value free and stressed facts and principles rather than moral implications.
2. The subject matter was new to the students in that it was not an existing part of the regular curriculum used within the state.
3. Integrity and accuracy of the lessons were established.
4. Different teaching modes were typified by the two modules.
5. The two modules were equally appealing to the students.

The two teaching modes were designated as expository and guided discovery by Stout (1977), the curriculum writer. The modes differed primarily in the extent to which teacher talk was cast as statements or questions. The expository mode relied heavily upon illustrated lecture. The guided discovery mode was characterized by teacher questioning of why, what, and how. The central subject matter topics were the same for both modes.

A further distinction between the modes was the planned-for student

application of generalizations and principles. In the expository mode the generalizations were presented by the teacher-researcher within the context of appropriate application. The students, however, were not encouraged, nor given opportunity, to apply the generalizations within the classroom. In the guided discovery mode the learners were presented stimuli which evidenced the generalizations, were encouraged to construct the generalizations, and were questioned as to the potential application of the generalizations. The modes have been presented in detail by Stout (1977).

Each mode was implemented in six of the classrooms for the series of ten lessons contained in the assigned module. Two researchers served as the teachers in order to maximize control over teacher differences. The teacher-researchers reviewed together each lesson prior to the teaching and listened to each other's tapes of a majority of the lessons. An outside judge also reviewed tapes of the classes to assure teacher-researcher adherence to the specified modes.

#### Data Collection

The data collection extended over a four-month period. Four kinds of data about the learners were central to the purpose of this research. Each was obtained in a manner which allowed computer processing. A student identification number used by the school or one issued by the researcher was associated with each type of information. All data were coded as to class, teaching mode, teacher and type of information. When the data had been transferred to IBM cards, the card deck was

listed and compared to the original sources for accuracy.

All learners took the Hidden Figures Test prior to participating in the energy management lessons. In all but one school the regular classroom teacher administered the test without comment as to how the scores would be used. The researcher instructed the classroom teacher in the test administration procedures and issued the appropriate number of tests and answer sheets. The answer sheets were computer key punched and scored by a university testing facility.

Background data were recorded by school personnel onto IBM coding forms. Each school was provided with directions for completing the form (see Appendix H). Along with the students' identification numbers, the sex, grade in school, and composite percentiles on the Iowa Test of Educational Development were key punched and verified for accuracy.

After the energy management lessons were taught, the teacher-researcher administered the Energy Management and Inquiry Process Tests to each class within one class period. Students in all schools had at least 20 minutes to complete each test using answer sheets. The student answers, identification numbers and research codes were read by optic scanning equipment and key punched directly by the computer.

### Design

As indicated in Table 4, the treatments were assigned so that a partial balance of conditions and teachers was achieved. A control for teacher was introduced into the design. In this study precautions were taken to hold teacher differences to a minimum in an effort to avoid a



Table 4. Design for the study

Teacher	Teaching mode	
	Expository	Guided discovery
X	School 3 Class 2 of 2	School 3 Class 1 of 2
	School 4 Class 2 of 2	School 1 Class 1 of 1
	School 5 Class 2 of 2	School 7 Class 1 of 3
Y	School 7 Class 3 of 3	School 7 Class 2 of 3
	School 2 Class 1 of 1	School 4 Class 1 of 2
	School 6 Class 1 of 1	School 5 Class 1 of 2

large Teacher Method interaction (see page 57).

#### Statistical Analysis

Since the design did not allow representation of all possible comparisons, the analysis of variance was done through a regression procedure. Dummy variables were constructed for the effect of Teacher (T), Teaching Mode (M), and the interaction between these effects. Classroom means were computed, and the analysis was performed on these unweighted means. The means were used to avoid inflating the degrees of freedom for the error term by the interaction of students within

classrooms, since the achievement of learners is not independent from one learner to another within a classroom (Snedecor & Cochran, 1976). It was assumed that school effects were taken out by the covariates.

The variables of Cognitive Style (C) and Past Achievement (A) were handled as covariates since these prior conditions were not influenced by the classroom. The measures of these constructs were the Hidden Figures Test—CF-1 and the Iowa Test of Educational Development respectively. The number of minutes each class met for instruction varied, therefore, Minutes was also treated as a covariate. The residual from the effects mentioned above was used as the error term.

The model was

$$Y_{ijk} = T_i + M_j + (TM)_{ij} + B_C X_{kC} + B_A X_{kA} + B_t X_{kt} + E_{ijk}$$

with the following allocation of degrees of freedom:

	df
Teacher	1
Mode	1
Teacher x Mode	1
Cognitive style	1
Achievement	1
Minutes	1
Error	<u>5</u>
Total (classrooms)	11

Because of the parsity of degrees of freedom in the analyses alluded to above, and the unbalanced nature of the data, it was judged inadvisable to include the Mode by Cognitive Style interaction. This

effect was assessed by regressing the dependent variables on the measure of cognitive style for each classroom separately. If field-dependence-independence is more related to achievement for the guided discovery mode than the expository mode, these regression coefficients should be larger for students taught by the former mode than those taught by the latter mode.

## FINDINGS AND DISCUSSION

The findings of this study were generally negative. The full model explained nothing significant, and no significant differences were found relative to any of the hypotheses.

The purpose of the study was to explore the possible relationship of the learner trait of field-dependence-independence and the mastery of inquiry process skills or subject matter achievement when the teaching mode was either expository or guided discovery in nature. The effects of the independent variables and the covariates upon both dependent variables, Inquiry Process Mastery and Subject Matter Achievement, were determined using the model

$$Y_{ijk} = T_i + M_j + (TM)_{ij} + B_C X_{kC} + B_A X_{kA} + B_t X_{kt} + E_{ijk}$$

where C = the field-dependence-independence cognitive style, A = past achievement as measured by the Iowa Test of Educational Development, T = teacher, M = teaching mode, and t = minutes of instruction. The specific hypotheses tested are presented followed by the findings.

### Findings

Hypothesis 1a: Mastery of inquiry process skills is the same whether the teaching mode is expository or guided discovery.

The scores on the Inquiry Process Assessment Items were the dependent variable for the test of Hypothesis 1a. No main effect for Teaching Mode was found. The failure to find this effect cannot be accounted

for by biasing effects since the Teacher effect, the Instructional Mode by Teacher interaction, and Minutes of Instruction were not significant (see Table 5).

Table 5. Summary of analysis of variance for mastery of inquiry process skills

Source of variation	df	Sum of squares	Mean squares	F-ratio <sup>a</sup>
Model	(6)	(13.27)	2.21	(.74)
Teaching mode	1	1.40		.47
Teacher	1	.78		.26
Mode x Teacher	1	.09		.03
Minutes of Instruction	1	.09		.03
Hidden Figures Test	1	.62		.21
Iowa Test	1	6.03		2.01
Error	5	15.01	3.00	
Corrected total	11	28.28		

$$^a F_{6,5} = 4.95 \leq .05, 3.40 \leq .10; F_{1,5} = 6.61 \leq .05, 4.06 \leq .10.$$

Hypothesis 1b: Mastery of inquiry process skills does not depend on performance on the Hidden Figures Test.

The data also failed to reject Hypothesis 1b. Hence, mastery of inquiry process skills does not depend on the cognitive style of field-dependence-independence as measured by performance on the Hidden Figures Test—CF-1 (see Table 5).

Hypothesis 1c: Mastery of inquiry process skills does not depend on past academic achievement as measured on the Iowa Test of Basic Skills.

For Hypothesis 1c a higher but nonsignificant F value was found. In this study past achievement as measured on the Iowa Test of Educational Development did not contribute significantly to the performance on the Inquiry Assessment Items.

Hypothesis 2a: Subject matter achievement is the same whether the teaching mode is expository or guided discovery.

As is evident from Table 6, the effect of Teaching Mode was not significant. Again, the potentially biasing sources of variance were not significant.

Table 6. Summary of analysis of variance for subject matter achievement

Source of variation	df	Sum of squares	Mean squares	F-ratio <sup>a</sup>
Model	(6)	(13.77)	2.29	(1.09)
Teaching mode	1	2.59		1.23
Teacher	1	.55		.26
Mode x Teacher	1	.65		.31
Minutes of Instruction	1	.00		.00
Hidden Figures Test	1	.22		.10
Iowa Test	1	10.05		4.77
Error	5	10.52	2.10	
Corrected total	11	24.29		

<sup>a</sup> $F_{6,5} = 4.95 \leq .05, 3.40 \leq .10; F_{1,5} = 6.61 \leq .05, 4.06 \leq .10.$

Hypothesis 2b: Subject matter achievement does not depend on performance on the Hidden Figures Test.

Performance on the Hidden Figures Test was not significantly related to the scores on the subject matter achievement test, as indicated by the nonsignificant F value in Table 6. This finding is essentially the same as was found for Hypothesis 1b.

Hypothesis 2c: Subject matter achievement does not depend on academic achievement as measured on the Iowa Test of Basic Skills.

A nonsignificant F value was found for the effect of the Iowa Test of Educational Development (see Table 6). Subject matter achievement did not depend upon past achievement.

Hypothesis 3a: Mastery of inquiry process skills is the same for relatively field-dependent and field-independent learners whether the teaching mode is expository or guided discovery.

Beta weights were computed to investigate Hypothesis 3a. For all twelve classrooms the regression of the Inquiry Assessment Items scores on the Hidden Figures Test performance were positive, but not significant. This tendency for less field-dependent students toward higher problem-solving scores existed whether the teaching mode was expository or guided discovery. Therefore, there was no reason to reject the null hypothesis.

Hypothesis 3b: Subject matter achievement is the same for relatively field-dependent and field-independent learners whether the teaching mode is expository or guided discovery.

The interaction of teaching mode with cognitive style on subject matter achievement was also found to be not reliable. The beta weights for the regression of the Energy Management Test on the Hidden Figures

Test were computed for each classroom. For the six expository classrooms these values were in the expected positive direction, but none were significant. While none of the betas for the guided discovery classrooms were significant, one was negative. No other unique qualities of the classroom which evidenced the negative relationship were suggested by the data. On this basis there is no reason to suspect an interaction of cognitive style and teaching mode.

### Discussion

Sex differences were apparent for all measures collected. While the range of scores for males and females on the Iowa Test of Educational Development, the Hidden Figures Test and both dependent measures were similar, the mean scores on all measures were higher for males than for females (see Table 7). It seemed reasonable that males and females who enrolled in home economics might differ in many ways. Analysis of the data for only females was completed and the results were not significant. Speculations about the influences of the sex of students enrolling in home economics classes on the dependent measures are beyond the scope of the present study because further reduction of the sample size would make it too small.

The data evidenced initial differences among the classes in the sample. Since classes were assigned to treatments without knowledge of these differences, it was thought that extreme differences between classes receiving the treatments would not exist. However, by chance the three classes with the highest mean scores on the Iowa Test of



Table 7. Mean scores for all students and for males and females

	Range	Number	Mean
Hidden Figures			
All students	0-25	173	$\bar{X} = 9.01$
Males	2-25	35	$\bar{X} = 10.82$
Females	0-24	138	$\bar{X} = 8.55$
Iowa Test of Educational Development			
All students	.01-.99	161	$\bar{X} = 48.52$
Males	.01-.99	35	$\bar{X} = 57.00$
Females	.01-.93	126	$\bar{X} = 46.16$
Inquiry Process			
All students	3-22	176	$\bar{X} = 14.28$
Males		35	$\bar{X} = 16.34$
Females		141	$\bar{X} = 13.77$
Energy Management			
All students	4-23	177	$\bar{X} = 13.65$
Males		35	$\bar{X} = 16.37$
Females		142	$\bar{X} = 12.98$

Educational Development all received the guided discovery mode from teacher Y (see Table 8). As is evident from the means for the three classes in each teacher treatment combination, the initial differences were accompanied by achievement differences in the same direction with the exception of a reversal of small numeric value for the two lowest means (see Table 8). The raw scores from which these means were

Table 8. Means of classroom means for the covariates and dependent variables by teacher and method<sup>a</sup>

	Expository means	Guided discovery means
Covariates		
Hidden Figures Test		
Teacher X	9.79	7.03
Teacher Y	8.81	10.08
Iowa Test of Basic Skills		
Teacher X	45.41	42.35
Teacher Y	39.79	60.65
Dependent variables		
Inquiry Process Assessment Items		
Teacher X	14.20	13.27
Teacher Y	14.17	15.32
Energy Management Test		
Teacher X	13.88	13.24
Teacher Y	13.45	14.05

<sup>a</sup>N = 12, 3 in each cell.

generated are listed in Appendix I.

These findings partially support those of Grieve and Davis (1971), who found that neither cognitive style nor instructional mode had an overall effect on high school students' learning of the geography of Japan. They, however, did find deficits in knowledge acquisition among global, field-dependent, males receiving expository instruction. Further they found increased higher learning scores for analytical, field-independent, learners regardless of teaching method.

Productive comparisons of findings with the geography study are

not possible due to differences in methodology. The Grieve and Davis (1971) study assigned subjects from two schools into treatments on the basis of scores on the Hidden Figures Test. Bodine (1975) attributed the benefits of discovery methods for the more field-dependent learners reported by Grieve and Davis (1971) to the compatibility of the social orientation of field dependents with the interaction pattern in discovery classes. The present study dealt with intact classes the social structure of which was established prior to the treatment. The effect of preexisting social patterns may have suppressed the intended effects of the teaching modes on the student verbal interaction. Hence differences for field-dependent and field-independent students receiving the two modes of instruction may have been limited by the prevailing social patterns.

Further, Grieve and Davis (1971) reported using a median split of a score of 18.75 on the Hidden Figures Test. In the present study the median, while appropriately not used in the statistical analysis, was 8.25. Also, extreme field-independent subjects were identified by Grieve and Davis as those who scored over 22 on the Hidden Figures Test. Only five learners in the present study received scores above 22. The present sample was essentially field dependent in terms of the Grieve and Davis study and below the mean, 11.17 which characterized Bodine's (1975) mixed field-dependent-independent group. Such differences in the characteristics of the sample limit comparisons of the findings.

In addition, the teaching modes used in this study, while judged different, may not have been different enough in ways that would affect

different types of learning. The desire of the researchers to teach in ways so similar to each other that no teacher differences would be found may have severely restricted the extent to which discovery modes were implemented throughout the range of subject matter for the series of ten lessons.

In this study a reliable relationship between the learner trait, field-dependence-independence, and the two measures of achievement was not found for either the expository or the guided discovery mode of instruction. Further, the interaction of cognitive style was not significant for either mode of instruction. The initial differences among the cells were paralleled by differences in mastery of inquiry skills and subject matter achievement. Therefore, the tendency of less field-dependent learners toward higher achievement could not be attributed to either treatment.

## SUMMARY AND RECOMMENDATIONS

Research designed to determine the importance of considering the relative field-dependence-independence of learners in the selection of appropriate teaching modes is not conclusive. While the trait of field dependence versus field independence is one of the most widely studied cognitive styles, sufficient evidence of its influence on the classroom behavior of learners has not been collected. Because persons' scores on the trait are associated with persistent ways of behaving, implications for the planning of classroom activities need to be documented. For instance, relatively field-dependent persons may need specific help in ordering concepts when the teaching mode is guided discovery.

Learning outcomes which need to be assessed are of many types. Among these are both content and process objectives.

The present study was designed to explore the effect of the field-dependence-independence cognitive style in classrooms taught by expository and guided discovery modes of instruction. The acquisition of subject matter and the mastery of inquiry skills were assessed in this study. The specific objectives of the study were:

1. To determine if classrooms of learners which were taught in an expository mode differed from those taught in a guided discovery mode on measures of inquiry process or subject matter achievement, and
2. To identify a possible trait treatment interaction of the learners' cognitive style with an expository or guided

discovery teaching mode.

The investigation of a possible relationship of the cognitive style of relatively field-dependent persons versus relatively field-independent persons was carried out in 12 high school home economics classrooms within seven schools near Ames, Iowa. The subjects were enrolled in comprehensive home economics programs for youths of sophomore through senior standing.

Two researchers served as the regular classroom teachers for the 10 days' lessons. A balance of treatment modes for each teacher-researcher was obtained in the assignment of classrooms to treatments. That is, each taught six classes, three in the expository mode and three in the guided discovery mode. There was no reason to believe that the average ability of learners in the classrooms would differ greatly since assignment to conditions was not based upon measured ability.

The treatments consisted of a series of ten lessons on energy management described in teaching modules designed to guide lessons in an expository and a guided discovery mode. The modules were developed in a companion study and were judged to provide for equally attractive lesson series.

Four types of data were obtained for each learner. The Iowa-normed composite percentile on the Iowa Test of Educational Development obtained from school records was used as a measure of the past achievement of the learners. The Hidden Figures Test—CF-1 was administered prior to the treatment, and the raw scores used to indicate the learners'

relative standing on the field-dependence-independence trait. After the treatment, subject matter objectives of the knowledge and application levels of the cognitive domain were assessed using an instrument developed for this study. Scores were also obtained on the Inquiry Process Assessment Items, a subject matter free device designed to measure mastery of the skills requisite to successful inquiry.

The dependent variables of interest were subject matter achievement, as measured by a test developed for the research, and mastery of inquiry skills, as measured by the Inquiry Process Assessment Items. An analysis of variance using a regression format was performed to determine the effect on these variables of Teaching Mode, Teacher, Teacher by Teaching Mode, and the covariates, Minutes of Instruction, field-dependence-independence as measured on the Hidden Figures Test, and past achievement, as measured on the Iowa Test of Educational Development.

Further, the two achievement scores were regressed on the field-dependence-independence scores of the students in each classroom. The latter test was not included in the original analysis of variance due to the small and unequal n's in the classrooms and the available degrees of freedom. All tests were also completed for the 138 females in the original sample of 177 for whom all data were available. Analysis for the 35 males was not performed due to the small number and unequal representation of males.

The findings of this study were generally negative. The full model explained nothing significant, and no significant differences were found relative to any of the hypotheses. Subject matter achievement

and mastery of inquiry skills was essentially the same for both teaching modes. Similarly neither the performance on the field-dependent-independent measure nor past achievement accounted for significant differences in achievement. Further, the effect of the Teacher, the Teaching Mode, the Teacher by Teaching Mode interaction, and the Minutes of Instruction did not explain a significant amount of variance. The regression of the dependent variables on the Hidden Figures Test scores was not reliable. The results for the females in the sample were also nonsignificant.

Several factors could have contributed to the lack of significant findings. The range of scores on the Hidden Figures Test was restricted with the highest scores for both sexes and for the total being lower than those reported in other studies of high school students. Under other circumstances low hidden figures scores could be interpreted as evidence of field dependents being attracted to the personable and sociable image of home economics. However, in this study all females of a particular grade in some schools were present in the sample. An investigation of the possible differences on this cognitive style between subjects of the midwestern rural background of this sample and samples drawn from students living within or in close proximity to major cities might provide a basis for a refinement of field-dependence-independence theory.

It is further possible that students who are relatively more field dependent or field independent adjust to new teachers and unfamiliar modes of instruction at different rates. Evidence related to this



possibility is recommended before further investigations of this type are carried out.

While the teaching modes employed in this study were judged to be different, the differences may not have been of a sufficient magnitude to provide learning situations which differentially affected field dependents and field independents. Further, the guided discovery classes may not have provided sufficient opportunities for student resolution of planned puzzlements, a condition which is thought by some to be a needed reinforcement of productive thinking patterns if skills of inquiry are to be improved.

The above mentioned problem could be alleviated by the use of a coding system as an outside criterion for establishing adherence to either the expository or the guided discovery teaching mode. The coding system needed would specify the relative percentage of student and teacher talking, relevant student to student remarks, evidence of planned student initiated inquiry, thoughtful silence, and other related classroom behavior.

A frequent problem of research of this type is teacher differences. The procedure followed in this study to protect against this confounding variable was effective and worth consideration for use in other studies.

Based upon the results of this study it is recommended that the aforementioned confounding variables be controlled. The potential contribution of increased understanding of the effects of field-dependence-independence to the planning of educational activities designed to support the goal of helping students to increase and perfect their thinking skills is worthy of further research.

## SELECTED REFERENCES

- Berliner, D. C., and Cahen, L. S. Trait-treatment interaction and learning. In F. N. Kerlinger (Ed.), *Review of research in education* (Vol. 1). Itasca, Illinois: F. E. Peacock, 1973.
- Bloom, B. S. *Human characteristics and school learning*. New York: McGraw-Hill, 1976.
- Bloom, B. S. (Ed.). *Taxonomy of educational objectives, handbook I: Cognitive domain*. New York: David McKay, 1956.
- Bodine, R. L. *The effects of cognitive style, task structure, and task setting on student performance*. Unpublished doctoral dissertation, Purdue University, 1975.
- Borg, W. R., and Gall, M. D. *Educational research*. New York: David McKay, 1971.
- Bracht, G. H., and Glass, G. U. The external validity of experiments. *American Educational Research Journal*, 1968, 5, 437-474.
- Brun, J. K. K. *An observational method for studying classroom cognitive processes*. Unpublished doctoral dissertation, Iowa State University, 1970.
- Bruner, J., Goodnow, J. J., and Austin, G. A. *A study of thinking*. New York: Science Editions, Inc., 1967.
- Educational Testing Service. *Hidden Figures Test—CF-1*. Princeton, New Jersey: Author, 1962.
- Feij, J. A. Field independence, impulsiveness, high school training, and academic achievement. *Journal of Educational Psychology*, 1976, 68, 793-799.
- Grieve, T. D., and Davis, J. K. The relationship of cognitive style and method of instruction to performance in ninth grade geography. *Journal of Educational Research*, 1971, 65, 137-141.
- Guetzkow, H. An analysis of the operation of set in problem-solving behavior. *Journal of General Psychology*, 1951, 45, 219-244.
- Hausafus, C. *Computer simulation for writing and evaluating multiple choice items*. Doctoral dissertation in progress, Iowa State University, ca. 1977.

- Hoover, H., and Cauble, A. Concept versus expository method of teaching family relationships. *Home Economics Research Journal*, 1974, 3, 136-141.
- Horrocks, J. E. The relationship between knowledge of human development and the use of such knowledge. *Journal of Applied Psychology*, 1946, 30, 501-507.
- Hughes, R. P. Measuring relationships among and between cognitive and affective behaviors in a controlled learning situation (Vol. 1). Ithaca, New York: Cornell University, 1968.
- Humphreys, L. G., and Parsons, C. K. Partialing out intelligence: A methodological and substantive contribution. *Journal of Educational Psychology*, 1977, 69, 212-216.
- Iowa Department of Public Instruction. "Family Educational Rights and Privacy Act of 1974:" A model policy and rules (Rev. ed.). Des Moines, Iowa: Author, 1976.
- Joyce, B., and Weil, M. Models of teaching. Englewood Cliffs, New Jersey: Prentice-Hall, 1972.
- Kizer, D. J. Cognitive interaction and learning in home economics classes. Unpublished doctoral dissertation, Iowa State University, 1973.
- Kogan, N. Educational implications of cognitive styles. In G. S. Lesser (Ed.), *Psychology and educational practice*. Glenview, Illinois: Scott, Foresman, 1971.
- Koran, M. L., Snow, R. E., and McDonald, F. J. Teacher aptitude and observational learning of a teaching skill. *Journal of Educational Psychology*, 1971, 62, 219-228.
- Lezotte, L. W. The relationship between cognitive styles, scholastic ability and the learning of structured and unstructured materials. Unpublished doctoral dissertation, Michigan State University, 1969. (University Microfilms No. 70-228, 229)
- Martinez-Brawley, E. E. Beyond didactics, heuristics, and philetics. *Peabody Journal of Education*, 1977, 54, 82-87.
- Messick, S., and Associates. Individuality in learning. San Francisco: Jossey-Bass, 1976.
- Murphy, P. D., Cavanaugh, H. P., Geer, C., Pihal, J., Elsbernd, L., and Norman, M. Consumer education curriculum modules: A spiral-process approach. Washington, D.C.: U.S. Government Printing Office, 1974.

- Nelson, H. Y., and Jacoby, G. P. Evaluation of secondary school programs to prepare students for wage earning in health care occupations related to home economics. Ithaca, New York: Cornell University, 1968.
- Quinlan, D. M., and Blatt, S. J. Field articulation and performance under stress: Differential predictions in surgical and psychiatric nursery training. *Journal of Consulting and Clinical Psychology*, 1972, 39, 517.
- Satterly, D. J. Cognitive styles, spatial ability, and school achievement. *Journal of Educational Psychology*, 1976, 68, 36-42.
- Scott, J. A., and Frayer, D. A. Learning by discovery: A review of the research methodology. Madison: Wisconsin Research and Development Center for Cognitive Learning, 1970.
- Smith, R. B. A discussion of an attempt at constructing reproducible item sets. *Journal of Educational Measurement*, 1968, 5, 55-60.
- Snedecor, G. W., and Cochran, W. G. Statistical methods (6th ed.). Ames, Iowa: Iowa State University Press, 1976.
- Spitze, H. T. Teaching strategies to promote thinking. *Illinois Teacher for Contemporary Roles*, 1968-69, 12, 132-137.
- Stout, B. L. Effect of two methods of instruction on level of achievement and attitude of high school home economics students. Unpublished doctoral dissertation, Iowa State University, 1977.
- Suchman, J. R. The elementary school training program in scientific inquiry. Urbana: University of Illinois, 1962.
- Taba, H. Teaching strategies and cognitive functioning in elementary school children. San Francisco: San Francisco State College, 1966.
- Taba, H., and Elzey, F. F. Teaching strategies and thought processes. *Teachers College Record*, 1964, 31, 524-534.
- Tanner, R. T. Expository versus discovery-inductive programing of physical science principles. Unpublished doctoral dissertation, Stanford University, 1968. (University Microfilms No. 68-15102).
- TenBrink, T. D. Evaluation: A practical guide for teachers. New York: McGraw-Hill, 1974.
- Thelen, H. Education and the human quest. New York: Harper and Row, 1960.

- Thorndike, R. L. (Ed.). Educational measurement. Washington, D.C.: American Council on Education, 1971.
- Thornell, J. G. Research on cognitive styles: Implications for teaching and learning. Educational Leadership, 1976, 33, 502-504.
- Tobias, S., and Ingber, T. Achievement-treatment interaction in programmed instruction. Journal of Educational Psychology, 1976, 68, 43-47.
- Witkin, H. A. In S. Messick and Associates, Individuality in learning. San Francisco: Jossey-Bass, 1976.
- Witkin, H. A. The role of cognitive style in academic performance and in teacher-student relations. New Jersey: Educational Testing Service Research Bulletin, 1973.
- Witkin, H. A., and Moore, C. A. Cognitive style and the teaching-learning process. Paper presented at the meeting of the American Educational Research Association, Chicago, Illinois, April 1974.
- Witkin, H. A., Moore, C. A., Goodenough, D. R., and Cox, P. W. Field-dependent and field-independent cognitive styles and their educational implications. Review of Educational Research, 1977, 47, 1-64. (a)
- Witkin, H. A., Moore, C. A., Oltman, P. K., Goodenough, D. R., Friedman, F., Owen, D. R., and Raskin, E. Role of the field-dependent and field-independent cognitive styles in academic evolution: A longitudinal study. Journal of Educational Psychology, 1977, 69, 197-211. (b)
- Witkin, H. A., Cox, P. W., Friedman, F., Hrishikeshan, A. G., and Siegel, K. N. Supplement No. 2, Field-dependence-independence and psychological differentiation: Bibliography with index. Princeton, New Jersey: Educational Testing Service, 1976.
- Witkin, H. A., Cox, P. W., Friedman, F., Hrishikeshan, A. G., and Siegel, K. N. Supplement No. 1, Field-dependence-independence and psychological differentiation: Bibliography with index. Princeton, New Jersey: Educational Testing Service, 1974.
- Witkin, H. A., Oltman, P. K., Cox, P. W., Ehrlichman, E., Hamm, R. M., and Ringler, R. W. Field-dependence-independence and psychological differentiation: A bibliography through 1972 with index. Princeton, New Jersey: Educational Testing Service, 1973.

## ACKNOWLEDGMENTS

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The research would not have been possible without the kind cooperation of the administrators, home economics teachers, and students of the participating Iowa schools. The assistance of the state home economics consultants in identifying these participating schools is appreciated.

I owe deepest gratitude to my family and the coordinator of the companion study for evidencing their support and understanding throughout the research.

**APPENDIX A: LICENSING AGREEMENT**

81  
LICENSING AGREEMENT

THIS AGREEMENT, entered into as of March 11, 1977, between Educational Testing Service (hereinafter called "ETS"), a nonstock, nonprofit corporation organized and existing under the Education Law of the State of New York, with offices at Princeton, New Jersey 08540, and

Ms. Helen Pyle Njus  
Route 2  
Story City, Iowa 50248

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Helen Pyle Njus

EDUCATIONAL TESTING SERVICE

By Russell W. Martin, Jr.  
Russell W. Martin, Jr.  
Title Assistant Treasurer



*Handwritten initials or mark in the bottom right corner.*

**APPENDIX B: LETTER FROM EDUCATIONAL TESTING SERVICE**

EDUCATIONAL TESTING SERVICE

PRINCETON, N. J. 08540

Area Code 609  
921-9000  
C1511-EDUCTESTSUC

Richard W. Martin  
Assistant Treasurer

March 11, 1977

Ms. Helen Pyle Njus  
Route 2  
Story City, Iowa 50248

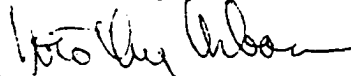
Dear Ms. Njus:

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If these arrangements are satisfactory, please sign both copies of the Agreement, and return one copy of the Agreement along with your payment to Mr. Martin.

Sincerely,



(Mrs.) Dorothy Urban  
Copyrights, Licensing and  
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DU/ls

Enclosures

cc: Mr. Dermen  
Mrs. Ekstrom

**APPENDIX C: LETTER TO PARTICIPATING SCHOOLS**

IOWA STATE  
UNIVERSITY

Telephone 515-294-6444

DATE: February 18, 1977

TO: Schools participating in the Energy Management Project

The Energy Management project is part of an on going departmental research program. The purpose of the study is to identify advantages of certain instructional methods in terms of learner achievement for different kinds of students.

In order to identify learners who are better served by a particular mode of instruction, data from the students' files are needed as indicators of past achievement and ability. We wish to assure you that we will not allow any association of individual student's names in reports of the data. Further, no school will be identified with specific data in any reports of the study.

The information needed in the study is permitted according to the Iowa Department of Public Instruction publication, "Family Educational Rights and Privacy Act of 1974:" A Model Policy and Rules (Revised). The policy statement is as follows:

XIV. Source of Requests for Information

G. Other

No other person may have access to any data in a student's record except under one of the following circumstances:

2. When data for outside research purposes are obtained in such a manner that no individual student is identifiable. (pp 11-12)

Please direct any questions regarding the nature of the research to Ruth P. Hughes (phone number 294-6444, Ames).

Ruth P. Hughes  
Professor and Head  
Home Economics Education

Helen Njus  
Project Instructor

Betty Stout  
Project Instructor

HN/deb

**APPENDIX D: INQUIRY PROCESS ASSESSMENT ITEMS**

## INQUIRY PROCESS ASSESSMENT ITEMS

**DIRECTIONS:** Mark the ONE best answer for each of the following 25 questions on your answer sheet.

1. In 1972, there were 2 ducks for each duck hunter.

In 1973, the number of ducks was less than the number of duck hunters.

Which of the following questions is **least important** in determining what the ratio of ducks to hunters will be in 1974? Check the blank preceding that question.

- ☐ A. Will the hunting of ducks be permitted in 1974?
- ☐ B. Do all hunters eat the meat of the duck?
- ☐ C. What was the birthrate of ducks in 1973?
- ☐ D. How many persons will come of hunting age in 1974?

2. Which question below is **least** relevant to a discussion about the conservation of paper? Check the blank preceding that question.

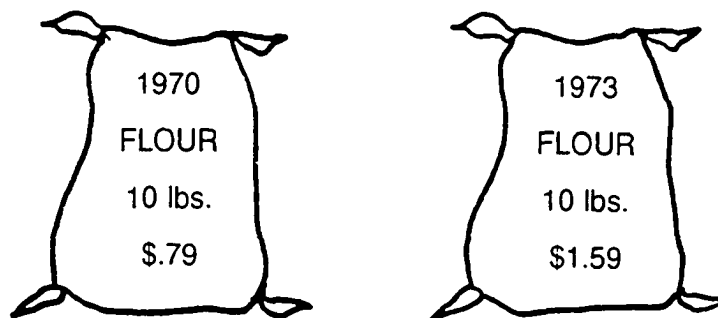
- ☐ A. How can the use of paper products be reduced?
- ☐ B. In what ways can recycled paper be used?
- ☐ C. What effect do forest fires have on the supply of paper products?
- ☐ D. What paper products are the least expensive to produce?

3. Check the blank preceding the **one** question below which is specific and which clearly identifies a purpose for inquiry.

- ☐ A. What was the cost of grain in 1970?
- ☐ B. If food prices continue to rise, will the rest of the economy be affected?
- ☐ C. What effect did a growing world population have on grain prices in the early 1970's?
- ☐ D. Who raises the bulk of the world's supply of grain?

4. You are in the library finding information related to the "causes of high grain prices in the early 70's." Check the blank preceding the information sample listed below which **best** aids you in studying the topic.

- \_\_\_ A. A graph showing the increase in grain prices from 1945-1973.
- \_\_\_ B. A census on the midwestern states for the years 1960-1970.
- \_\_\_ C. A descriptive report on world-wide weather conditions which have influenced crop production.
- \_\_\_ D. A price index for one specific date showing the selling price of various types of grain on the world market (wheat, barley, rice, oats, etc.).



5. Check the blank preceding the **one** question below which would best guide a person in inquiring about the situation represented by the flour sacks above.
- \_\_\_ A. What factors caused the price of flour to increase during the three-year period?
  - \_\_\_ B. What was the increase per pound of the price of flour during the three-year period?
  - \_\_\_ C. During what year did the price of flour increase the most?
  - \_\_\_ D. How much flour is used in the United States each year?



- 6-7. Joan and Bill were talking. Joan said that she believes that manufacturers should not be allowed to make products that pollute the environment. According to Joan, the government should set up and enforce anti-pollutant standards for all products and services. Bill argued that consumers should have the freedom to buy and use whatever they personally consider to be the best goods and services.

6. Check the blank preceding the **one** response below which accurately completes this sentence: Joan and Bill differ as to their beliefs about

- ☐ A. the effects of pollution upon the environment.
- ☐ B. the desirability of government control.
- ☐ C. individual responsibility in a democratic society.
- ☐ D. manufacturers' responsibility to consumers.

7. Based on the above information about Joan and Bill, check the **one** action below which is **not** likely to happen.

- ☐ A. Bill will urge his Congressman to vote for legislation to censor movies.
- ☐ B. Joan will ask the city council to conduct a city-wide paper drive.
- ☐ C. Joan will find out whether a local manufacturing plant is obeying the government regulations regarding the maximum amount of noise that workers are exposed to.
- ☐ D. Bill will buy products labeled "safe for the environment."

- 8-9. In 1920, there were 106 million people in the United States. Each created an average of three pounds of trash per day.

In 1971, there were 205 million people in the United States. Each created an average of six pounds of trash per day.

In 1980, the population of the United States is expected to be about 230 million people.

8. If a person were concerned about the situation described above, which **one** of the following questions would **best** guide him in finding meaningful information about the situation?

- ☐ A. Why do people create trash?
- ☐ B. Why did people create more trash in 1971 than they did in 1920?
- ☐ C. How much trash per year does each person in California create as compared with the amount created per person in the other states?
- ☐ D. How many pounds of trash will each person create in 1980?

9. Considering the information presented in the situation above, check the **one** response below which is an accurate statement.

- ☐ A. In 1980, each person is likely to create more than 6 pounds of trash each day.
- ☐ B. People's values influence the amount of trash they create.
- ☐ C. The amount of trash each person created reached a peak in 1971.
- ☐ D. As people's income increases, the amount of trash increases.

10. If one assumes that more land is needed to produce more food for the world population, what action could be taken to make more food-producing land available? Check the blank preceding the **one** response below which is a possible solution.

- ☐ A. Farmers could use more fertilizer.
- ☐ B. More synthetic (man-made) foods could be developed.
- ☐ C. More model cities could be built.
- ☐ D. Food could be raised on the ocean bottom.

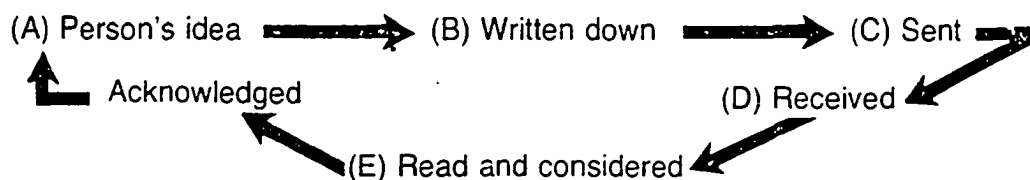
11. When the supply of beef remains constant and the consumer demand for beef increases, the price of beef is likely to increase. Based on this information, check the blank preceding the **one** action below which could be taken to help control an increase of the cost of beef.

- \_\_\_ A. Increase the amount of pork on the market.
- \_\_\_ B. Decrease the number of beef specials and sales in the grocery stores.
- \_\_\_ C. Increase the variety of meat substitutes available.
- \_\_\_ D. Ration the amount of beef each person may buy.

- 12-19. Communication is a circular process if it is effective. When a person gets an idea and wants to communicate it, he must put it into a form which can be understood by someone else. Writing a letter may be the next step of the process; then the letter must be sent to someone, received, read and considered, and acknowledged to the sender.

Look at the diagram and the statements about a written communication. Mark each statement with the letter of the **last** step of the process which the statement tells you was completed.

#### DIAGRAM OF A WRITTEN COMMUNICATION



#### STATEMENTS

- \_\_\_ 12. My letter is ready to go out in the afternoon mail.
- \_\_\_ 13. If the manager knew how his employee mistreated me, he might correct the problem.
- \_\_\_ 14. I heard from a friend that my letter was discussed in a management meeting.
- \_\_\_ 15. It's been two weeks since I mailed my request, but I've heard nothing.
- \_\_\_ 16. The secretary said my letter is on the president's desk unopened.
- \_\_\_ 17. I know my note went to the right person because I delivered it myself.

Consequences are the result of an action or thought. Look again at the "Diagram of a Written Communication" and check the **one** most likely consequence in each situation below.

18. If a company had a policy of sending the same form letter in response to any kind of complaint
- ☐ A. acknowledgements might be sent which had little to do with the original complaint.
  - ☐ B. people would write shorter letters to that company.
  - ☐ C. form letters should be sent to the company.
  - ☐ D. the employees of the company would know that all complaints were handled quickly and fairly.
19. If many people have lots of ideas about improving conditions for consumers but never told them to anyone .
- ☐ A. the quality of consumer goods and services would not improve.
  - ☐ B. it would be only by accident that a company would have the same ideas and put it into practice.
  - ☐ C. conditions would be better for all consumers because many problems would be solved.
  - ☐ D. a writing clinic would be held by businesses who wanted to know how their customers felt.

Comparison Shopping Chart for Identical Color TV's

TV Set	Store	Price Quoted	Guarantee and Service	Delivery Charge
Set A	Neighborhood Appliance Store	\$639.95	6 months on parts 2 years on picture tubes Store serviceman only	none
Set B	Downtown Dept. Store "Hardy's"	\$629.95	18 months on parts 2 yrs. on picture tubes 90-day labor guarantee Store serviceman only	none
Set C	Downtown Dept. Store "Public's"	\$629.95	12 months on parts 2 years on picture tubes Self-employed authorized serviceman only	\$20
Set D	Downtown Discount Department Store	\$609.95	12 months on parts 2 years on picture tubes Self-employed authorized serviceman only	\$15

20-23. The Gondola family is shopping for a color TV. They plan to pay cash for the set and wish to have it delivered.

Using the information from the above chart, answer the following questions by checking the blank preceding the **one** accurate response to each question.

20. Based on the information, which TV set costs the **most**?

\_\_\_ A. Set A

\_\_\_ B. Set B

\_\_\_ C. Set C

\_\_\_ D. Set D

21. Based on the information, which TV set costs the **least**?

\_\_\_ A. Set A

\_\_\_ B. Set B

\_\_\_ C. Set C

\_\_\_ D. Set D

22. Which TV set has the longest guarantee on parts?

- ☐ A. Set A
- ☐ B. Set B
- ☐ C. Set C
- ☐ D. Set D

23. Of the four stores, which provides the most services to the customer?

- ☐ A. Neighborhood Appliance Store
- ☐ B. Hardy's Downtown Department Store
- ☐ C. Public's Downtown Department Store
- ☐ D. Downtown Discount Department Store

- 24-25. Lorna is shopping for fresh fruit. She has noticed over the years that the prices of apples and grapefruit seem to be much lower during the winter months. She thinks that the price of fruit must be directly related to the supply available. To find out if her idea is correct, Lorna looks at the following chart published by the U.S. Department of Agriculture:

AVAILABILITY OF APPLES AND GRAPEFRUIT

G=Good Supply, F=Fair Supply, S=Small Supply												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Apples	G	G	G	G	F	S	S	S	G	G	G	G
Grapefruit	G	G	G	G	G	F	S	S	S	G	G	G
Cost of fruit per dozen												
Apples	.89	.89	.93	.93	1.20	1.49	1.49	1.49	.93	.93	.89	.89
Grapefruit	.99	.99	1.09	1.09	1.09	1.20	1.49	1.49	1.49	1.19	1.09	.99

24. Check the blank preceding the **one** sentence below which accurately states how the information in the chart affects Lorna's idea about the cost of apples and grapefruit.

- \_\_\_ A. The information supports her idea.
- \_\_\_ B. The information refutes (*does not support*) her idea.
- \_\_\_ C. The information is not sufficient to either support or refute her idea.

25. Based on the information in the chart above, check the blank preceding the **one** sentence below which is an accurate conclusion about the cost of apples and grapefruit.

- \_\_\_ A. As the availability of fruit increases, the cost per dozen increases.
- \_\_\_ B. As the availability of fruit increases, the cost per dozen decreases.
- \_\_\_ C. There is no consistent relationship between the availability of fruit and its cost.

APPENDIX E: LETTER TO JUDGES



January 14, 1977

To: Judges of cognitive level of test questions

From: Helen Pyle (Cavanaugh) Njus

It will be appreciated if you would serve as a judge of the level of the cognitive domain measured by each of the enclosed questions. You would be one of a three member panel whose opinion will affect the selection of items to be used to evaluate the newly developed energy management modules.

Other experts will judge the accuracy of the content tested. Your general knowledge of energy and energy management and familiarity with the modules is sufficient for purposes of evaluating the level of the questions.

Only two categories will be used to describe the level of each question. One category includes the knowledge level of Bloom's Taxonomy. The other category includes the application level.

The knowledge level questions will demand recall involving little more than bringing to mind the appropriate material.

To be judged application answering the question must necessitate more than simply understanding. These questions should require that the student deal with abstractions or apply technological principles, ideas, or theories. Questions which may demand more than the cognitive skills needed for the application level described by Bloom are also appropriately placed in this category of question.

The questions have been randomly ordered. Please mark each question as follows:

K = Knowledge level

A = Application level

Thank you for your help.

**APPENDIX F: ENERGY MANAGEMENT TEST**

ENERGY MANAGEMENT TEST

Mark your answer sheet according to the directions.

Use a pencil to mark the ONE best answer to each question.

1. Which of the following refers to the efficiency of a lamp?
  - A. amount of energy used to construct the lamp
  - B. energy required to produce light
  - C. length of time the light is on
  - D. sensitivity of the light switch
  
2. In which order were energy sources used as our country developed?
  - A. hydro, wind, solar
  - B. solar, nuclear, geothermal
  - C. wind, wood, coal
  - D. wood, gas, coal
  
3. Which of the following statements is based upon past truths about energy?
  - A. As energy sources are developed, new ways of using energy are found.
  - B. The greatest amount of energy is used when the supply is lowest.
  - C. Less energy is used as advances in technology are made.
  - D. The supply of energy exceeds the demands for energy.
  
4. Which of the following is a problem related to energy?
  - A. Americans use too much energy for nonessentials in their homes.
  - B. Generators do not have the capacity to meet peak load demands for electricity.
  - C. Industry uses more than its share of the available energy in the country.
  - D. Nonrenewable sources of energy provide for the majority of the nation's energy needs.

5. If fewer steps are used to refine kerosene than fuel oil, and coal is required to generate electricity, which of the following would be the most efficient fuel to use to boil water?
- A. alcohol
  - B. electricity
  - C. kerosene
  - D. oil
6. Which of the following is least likely to become a source of energy for heating homes in Iowa?
- A. corn stalks
  - B. geothermal
  - C. nuclear
  - D. tidal
7. Consider the lifestyle of each of the following people and decide which one probably uses the least (nonhuman) energy.
- A. Bill is 40 and a bachelor. He has a large apartment so that he can entertain friends and relatives. He walks to his work a mile away.
  - B. Joan is newly married. She and her husband both work in a nearby town. They have very busy schedules but always spend weekends working on their new home.
  - C. John sold his home when he moved into a retirement village with his wife. Their grandchildren often visit and enjoy vacations in Grandpa's modern camper van.
  - D. Susan is 15 years old. She lives with her parents and 2 brothers in an old farm house. Susan often catches the late bus home from school after cheerleading.
8. Who uses the most nonhuman energy?
- A. Charlie Brown
  - B. Dagwood
  - C. Li'l Abner
  - D. Superman

9. The major uses of energy in the home are
- A. clothes drying and washing.
  - B. entertainment and cleaning.
  - C. refrigeration and cooking.
  - D. space heating and water heating.
10. Which of the following remarks makes the most sense in terms of energy conservation?
- A. "Don't spend so long in the shower."
  - B. "Don't stand there looking into the refrigerator."
  - C. "If nobody is watching TV, turn it off."
  - D. "Turn off the light if you are not using it."
11. If you wished to have a solar heating system installed, your first consideration after looking at your budget would be
- A. environmental effects.
  - B. political implications.
  - C. public acceptance.
  - D. technological advancements.
12. Energy efficiency is
- A. greatest for small appliances.
  - B. how you use energy.
  - C. less than energy conversion
  - D. what you get compared to what you put in.
13. Which of the following would be most helpful if you were to compare the efficiency of two electric heaters?
- A. energy efficiency ratio of one
  - B. fan, extension cord, paper and pencil
  - C. thermometer and electric meter
  - D. thermostat and thermometer

14. You plan to buy an air conditioner for a room that is 20' x 20' with ceilings 8 feet tall. Which of the following air conditioners would be best for you?
- A. Cost--\$200, capacity--2000 cu. ft., EER = 7, range 5-8
  - B. Cost--\$300, capacity--3500 cu. ft., EER = 6, range 5-9
  - C. Cost--\$350, capacity--3500 cu. ft., EER = 7, range 5-10
  - D. Cost--\$400, capacity--5000 cu. ft., EER = 8, range 6-9
15. The energy required to heat a home is affected by the
- A. site and orientation of the house.
  - B. site, orientation, and design of the house.
  - C. site, orientation, design, and construction of the house.
  - D. site, orientation, design, construction and color of the house.
16. The most energy efficient home in terms of siting and orientation is one which is
- A. on level ground with the longest sides on the east and west.
  - B. partially underground and faces east.
  - C. protected by a hill from the north wind and faces south.
  - D. surrounded by trees and faces north.
17. Heat moves
- A. from higher temperature regions.
  - B. from lower temperature regions.
  - C. into higher temperature regions.
  - D. into regions of similar temperature.
18. When selecting an energy conserving apartment you could probably find one which
- A. faces the sun.
  - B. has a heat pump.
  - C. has a solar heating system.
  - D. has triple glazing.

19. On which of the following would an "R-number" be printed?
- A. electric range
  - B. gas bill
  - C. insulation
  - D. weather-stripping
20. If an indoor-outdoor thermometer, located on the north wall of a room read 45°F. inside when it was 0°F. outside, there would be reason to believe that
- A. air infiltration was a problem.
  - B. the heat vents were not working.
  - C. walls of the house were not insulated.
  - D. the plumbing would freeze.
21. Jim and Linda designed their house so that all clothes closets are on outside walls. The result of having the closets on exterior walls would be
- A. decreased air infiltration and lower fuel costs.
  - B. decreased heat transmission and lower fuel bills.
  - C. increased fire danger and no effect on heating or cooling.
  - D. increased conductivity and reduced resistance of walls.
22. The most important things to consider about an energy source when attempting to decide what could be used in homes are
- A. power lines, maintenance, installation, and location.
  - B. tradition, research, popularity, and profit.
  - C. transportation, supply, cost, safety, and life-style.
  - D. technology, economy, culture, and construction.
23. Which of the following energy sources would be most likely to become commonly used in the United States?
- A. electricity generated from agricultural products
  - B. heat from geysers and hot springs
  - C. light from phosphorescent materials
  - D. wind powered water pumps

24. The basic parts of any system for using solar energy in an active manner for heating are
- A. a device to collect the sun's rays, a means of storing the heat, and a way to transfer the heat to the living area.
  - B. an enclosed system which focuses the sun's rays into the areas of the home to be heated.
  - C. a reflector to transfer heat to a medium which can be circulated through the living areas.
  - D. a storage facility which allows separation of heated material from areas which have already lost heat.
25. In a solar home the living area might be heated by exposed pipes in the center of the house. The pipes would be hottest when the sun was hitting the collector. The disadvantage of this design would be that the house would be hottest
- A. at night and coldest in the afternoon.
  - B. during the day and coldest in the morning.
  - C. in the evening and coldest at night.
  - D. in the evening and in the morning.
26. If the solar collector for a home were built as a separate structure the main disadvantage would be in terms of
- A. building costs.
  - B. control of the system.
  - C. effect upon life-style.
  - D. heating efficiency.



**APPENDIX G: TEST BLUEPRINT ANNOTATED**

TEST BLUEPRINT ANNOTATED

Objectives to be tested for each lesson are listed below and identified by cognitive level. Questions referenced to the objectives are included with the correct response indicated for each.

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 1

Question referenced to objective: Recognize first sources of energy used in America.

- 2.<sup>1</sup> In which order were energy sources used as our country developed?
- A. hydro, wind, solar
  - B. solar, nuclear, geothermal
  - X<sup>2</sup> C. wind, wood, coal
  - D. wood, gas, coal

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 1

Question referenced to objective: Translate the solutions of past energy problems into implications for solving developing energy problems.

3. Which of the following statements is based upon past truths about energy?
- X A. As energy sources are developed, new ways of using energy are found.
  - B. The greatest amount of energy is used when the supply is lowest.
  - C. Less energy is used as advances in technology are made.
  - D. The supply of energy exceeds the demands for energy.

---

<sup>1</sup>Item number on Energy Management Test for this and successive items.

<sup>2</sup>X = correct response for this and successive items.

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 2

Question referenced to objective: Name a current energy problem.

4. Which of the following is a problem related to energy?
- A. Americans use too much energy for nonessentials in their homes.
  - B. Generators do not have the capacity to meet peak load demands for electricity.
  - C. Industry uses more than its share of the available energy in the country.
  - X D. Nonrenewable sources of energy provide for the majority of the nation's energy needs.

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 2

Question referenced to objective: Apply the second law of thermodynamics to a decision about the use of an energy source.

5. If fewer steps are used to refine kerosene than fuel oil, and coal is required to generate electricity, which of the following would be the most efficient fuel to use to boil water?
- A. alcohol
  - B. electricity
  - X C. kerosene
  - D. oil

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 3

Question referenced to objective: Name alternative choices in meeting an energy need.

6. Which of the following is least likely to become a source of energy for heating homes in Iowa?
- A. cornstalks
  - B. geothermal
  - C. nuclear
  - X D. tidal

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 3

Questions referenced to objective: Relate life-style and energy consumption.

7. Consider the life-style of each of the following people and decide which one probably uses the least (nonhuman) energy.
- A. Bill is 40 and a bachelor. He has a large apartment so that he can entertain friends and relatives. He walks to his work a mile away.
  - B. Joan is newly married. She and her husband both work in a nearby town. They have very busy schedules but always spend weekends working on their new home.
  - C. John sold his home when he moved into a retirement village with his wife. Their grandchildren often visit and enjoy vacations in Grandpa's modern camper van.
  - X D. Susan is 15 years old. She lives with her parents and 2 brothers in an old farm house. Susan often catches the late bus home from school after cheerleading.
8. Who uses the most nonhuman energy?
- A. Charlie Brown
  - X B. Dagwood
  - C. Li'l Abner
  - D. Superman

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 4

Question referenced to objective: Identify the major household uses of energy.

9. The major uses of energy in the home are
- A. clothes drying and washing.
  - B. entertainment and cleaning.
  - C. refrigeration and cooking.
  - X D. space heating and water heating.

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 4

Question referenced to objective: Distinguish between energy conservation practices which make an impact on the family's energy consumption, and those which do not.

10. Which of the following remarks makes the most sense in terms of energy conservation?
- X A. "Don't spend so long in the shower."
  - B. "Don't stand there looking into the refrigerator."
  - C. "If nobody is watching TV, turn it off."
  - D. "Turn off the light if you are not using it."

Question referenced to objective: Identify systems outside the family which have greatest influence on a particular energy situation.

11. If you wished to have a solar heating system installed, your first consideration after looking at your budget would be
- A. environmental effects.
  - B. political implications.
  - C. public acceptance.
  - X D. technological advancements.

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 5

Questions referenced to objective: Define energy efficiency.

12. Energy efficiency is
- A. greatest for small appliances.
  - B. how you use energy.
  - C. less than energy conversion.
  - X D. what you get compared to what you put in.
1. Which of the following refers to the efficiency of a lamp?
- A. amount of energy used to construct the lamp
  - X B. energy required to produce light
  - C. length of time the light is on
  - D. sensitivity of the light switch

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 5

Question referenced to objective: Compare the energy efficiency of appliances.

13. Which of the following would be most helpful if you were to compare the efficiency of two electric heaters?
- A. energy efficiency ratio of one
  - B. fan, extension cord, paper and pencil
  - X C. thermometer and electric meter
  - D. thermostat and thermometer

Question referenced to objective: Identify the appropriate use of the energy efficiency ratio.

14. You plan to buy an air conditioner for a room that is 20' x 20' with ceilings 8 feet tall. Which of the following air conditioners would be best for you?
- A. Cost--\$200, capacity--2000 cu. ft., EER = 7, range 5-8
  - B. Cost--\$300, capacity--3500 cu. ft., EER = 6, range 5-9
  - X C. Cost--\$350, capacity--3500 cu. ft., EER = 7, range 5-10
  - D. Cost--\$400, capacity--5000 cu. ft., EER = 8, range 6-9

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 6

Question referenced to objective: Name factors affecting the heating of homes.

15. The energy required to heat a home is affected by the
- A. site and orientation of the house.
  - B. site, orientation, and design of the house.
  - C. site, orientation, design, and construction of the house.
  - X D. site, orientation, design, construction, and color of the house.

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 6

Question referenced to objective: Analyze the use of the natural environment (sun and wind direction) in relation to siting, orientation, landscaping and design of a home.

16. The most energy efficient home in terms of siting and orientation is one which is
- A. on level ground with the longest sides on the east and west.
  - B. partially underground and faces east.
  - C. protected by a hill from the north wind and faces south.
  - X D. surrounded by trees and faces north.

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 7

Question referenced to objective: Recognize the relationship of heat flow to energy conservation.

## 17. Heat moves

- X A. from higher temperature regions.
- B. from lower temperature regions.
- C. into higher temperature regions.
- D. into regions of similar temperature.

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 7

Question referenced to objective: Determine the potential for involvement of the homeowner in energy-related decisions in various types of housing situations.

## 18. When selecting an energy conserving apartment you could probably find one which

- X A. faces the sun.
- B. has a heat pump.
- C. has a solar heating system.
- D. has a triple glazing.



## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 8

Question referenced to objective: Define "R-value"

19. On which of the following would an "R-number" be printed?
- A. electric range
  - B. gas bill
  - X C. insulation
  - D. weather-stripping

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 8

Questions referenced to objective: Apply energy management principles in making recommendations for insulating and weather-stripping in existing houses.

20. If an indoor-outdoor thermometer, located on the north wall of a room read 45°F. inside when it was 0°F. outside, there would be reason to believe that
- A. air infiltration was a problem.
  - B. the heat vents were not working.
  - X C. walls of the house were not insulated.
  - D. the plumbing would freeze.
21. Jim and Linda designed their house so that all clothes closets are on outside walls. The result of having the closets on exterior walls would be
- A. decreased air infiltration and lower fuel costs.
  - X B. decreased heat transmission and lower fuel bills.
  - C. increased fire danger and no effect on heating or cooling.
  - D. increased conductivity and reduced resistance of walls.

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 9

Question referenced to objective: List factors which determine the acceptability of alternative energy sources.

22. The most important things to consider about an energy source when attempting to decide what could be used in homes are
- A. power lines, maintenance, installation, and location.
  - B. tradition, research, popularity, and profit.
  - X C. transportation, supply, cost, safety, and life-style.
  - D. technology, economy, culture, and construction.

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 9

Question referenced to objective: Predict the acceptability of energy sources which are not in common use in the United States.

23. Which of the following energy sources would be most likely to become commonly used in the United States?
- X A. electricity generated from agricultural products
  - B. heat from geysers and hot springs
  - C. light from phosphorescent materials
  - D. wind-powered water pumps

## KNOWLEDGE LEVEL COGNITIVE QUESTIONS FOR LESSON 9-10

Question referenced to objective: Recognize the three (3) major components of solar systems.

24. The basic parts of any system for using solar energy in an active manner for heating are
- X A. a device to collect the sun's rays, a means of storing the heat, and a way to transfer the heat to the living area.
  - B. an enclosed system which focuses the sun's rays into the areas of the home to be heated.
  - C. a reflector to transfer heat to a medium which can be circulated through the living areas.
  - D. a storage facility which allows separation of heating material from areas which have already lost heat.

## APPLICATION LEVEL COGNITIVE QUESTIONS FOR LESSON 9-10

Questions referenced to objective: Given a description of a house design utilizing solar energy in a means different from that used in the class, the student will classify various aspects of the solar system, relate the solar system to the house design selected, predict the possible life-style changes necessitated and predict widespread support or rejection of the house.

25. In a solar home the living area might be heated by exposed pipes in the center of the house. The pipes would be hottest when the sun was hitting the collector. The disadvantage of this design would be that the house would be hottest
- A. at night and coldest in the afternoon.
  - X B. during the day and coldest in the morning.
  - C. in the evening and coldest at night.
  - D. in the evening and in the morning.
26. If the solar collector for a home were built as a separate structure the main disadvantage would be in terms of
- A. building costs.
  - B. control of the system.
  - C. effect upon life-style.
  - X D. heating efficiency.

**APPENDIX H: STUDENT BACKGROUND DATA**

STUDENT BACKGROUND DATA

School name \_\_\_\_\_ Code \_\_\_\_\_ Date \_\_\_\_\_

Classroom teacher \_\_\_\_\_ Form completed by \_\_\_\_\_

Principal \_\_\_\_\_ Guidance counselor \_\_\_\_\_

Complete IBM coding form as follows:

## Columns 16-21

Student ID number (Upper left corner on Des Moines computer printout)

## Column 23

Sex

0 = female, 1 = male

## Columns 24-25

Grade in school

09 = frosh, 10 = soph, 11 = junior, 12 = senior

## Columns 26-27

Iowa Test of Educational Development--Composite percentile rank

Iowa norms

## Columns 31-33

Spring 1976 Grade Point Average to two decimal places  
(hundredths in col. 33)

Include all courses for which a grade was issued

4 = A, 3 = B, 2 = C, 1 = D, 0 = F

## Columns 34

Check, "✓", if grading system is different from above, explain  
on back of this page.

## APPENDIX I: RAW DATA

In this appendix the raw data are arrayed in descending order of Hidden Figures Test score for each student. The column labels are: OBS = student observation number; O1 = Hidden Figures Test score; S = sex, 0 = female and 1 = male; GR = grade in school; SC = school and class code; IT = Iowa Test of Educational Development percentile rank; M = method, 1 = expository and 2 = guided discovery; T = teacher, 1 = teacher X and 2 = teacher Y; O2 = Energy Management Test score; and O3 = Inquiry Process Assessment Items score.

OBS	O1	S	GR	SC	IT	M	T	O2	O3
1	25	1	12	72	86	2	2	14	17
2	24	0	11	51	62	2	2	16	20
3	23	1	12	21	39	1	2	17	19
4	23	0	11	41	78	2	2	10	12
5	23	0	12	51	78	2	2	18	15
6	22	1	12	73	59	1	2	19	18
7	20	1	12	73	96	1	2	19	19
8	20	1	12	71	89	2	1	19	16
9	19	0	11	41	28	2	2	10	9
10	18	0	12	61	50	1	2	21	21
11	17	1	12	32	80	1	1	19	19
12	17	1	12	71	82	2	1	17	17
13	16	0	11	32	50	1	1	12	16
14	16	1	11	31	47	2	1	15	18
15	16	0	11	41	92	2	2	14	21
16	16	1	12	71	86	2	1	17	19
17	16	0	12	72	77	2	2	16	18
18	16	0	12	72	82	2	2	13	20
19	15	0	11	32	60	1	1	12	16
20	15	0	11	11	73	2	1	11	12
21	15	1	12	71	72	2	1	18	19
22	14	0	11	52	67	1	1	12	10
23	14	0	10	52	55	1	1	12	15
24	14	0	11	41	65	2	2	15	17
25	14	0	11	51	67	2	2	14	16
26	14	0	10	72	62	2	2	11	14
27	13	1	12	32	78	1	1	14	15
28	13	1	11	32	25	1	1	15	10
29	13	.	.	42	.	1	.	18	18
30	13	0	12	42	92	1	1	21	20
31	13	0	10	52	35	1	1	11	15
32	13	0	12	61	83	1	2	19	21
33	13	0	11	73	46	1	2	6	13
34	13	0	11	51	55	2	2	10	10
35	13	0	11	51	61	2	2	13	17
36	13	1	10	71	74	2	1	21	15
37	13	0	10	72	28	2	2	15	11
38	13	0	10	72	93	2	2	18	20
39	13	1	12	72	59	2	2	18	18
40	13	0	12	72	66	2	2	18	18
41	12	0	11	32	24	1	1	11	7
42	12	0	11	32	24	1	1	10	12
43	12	0	11	32	22	1	1	11	9
44	12	.	.	42	.	1	.	16	14
45	12	0	11	52	36	1	1	20	7

OBS	O1	S	GR	SC	IT	M	T	O2	O3
46	12	0	10	52	69	1	1	12	16
47	12	0	10	52	.	1	1	15	17
48	12	1	12	73	99	1	2	20	20
49	12	0	11	11	83	2	1	16	16
50	12	.	.	41	.	2	.	14	20
51	12	0	11	41	.	2	2	12	13
52	12	1	12	71	72	2	1	16	18
53	11	1	10	21	87	1	2	16	22
54	11	0	11	32	41	1	1	11	14
55	11	0	11	32	35	1	1	8	10
56	11	0	11	32	14	1	1	13	15
57	11	0	12	42	35	1	1	15	15
58	11	0	12	52	49	1	1	15	21
59	11	0	11	52	54	1	1	13	12
60	11	1	12	73	10	1	2	18	15
61	11	0	12	73	7	1	2	8	14
62	11	0	12	11	59	2	1	14	12
63	11	0	10	51	.	2	2	11	10
64	11	0	12	71	59	2	1	16	14
65	10	.	.	42	.	1	.	16	17
66	10	0	12	52	20	1	1	8	13
67	10	0	11	52	73	1	1	7	9
68	10	0	10	52	16	1	1	8	13
69	10	0	10	52	88	1	1	17	18
70	10	0	12	61	53	1	2	11	17
71	10	0	11	73	26	1	2	10	4
72	10	0	11	11	20	2	1	10	9
73	10	0	11	41	79	2	2	11	14
74	10	.	.	41	.	2	.	11	19
75	10	0	12	71	20	2	1	11	15
76	10	0	11	72	73	2	2	12	17
77	9	0	10	21	39	1	2	11	7
78	9	0	12	42	54	1	1	21	16
79	9	0	12	52	48	1	1	14	14
80	9	0	11	52	24	1	1	9	11
81	9	0	10	52	62	1	1	12	7
82	9	0	10	52	69	1	1	19	17
83	9	0	11	11	87	2	1	15	16
84	9	0	12	11	45	2	1	10	15
85	9	1	12	71	72	2	1	21	19
86	9	0	11	72	26	2	2	13	17
87	9	1	12	72	66	2	2	18	20
88	9	0	12	72	59	2	2	15	20
89	8	0	11	21	18	1	2	8	12
90	8	0	11	21	11	1	2	11	17



03	02	T	M	IT	SC	GR	S	01	08S
10	14	2	1	29	21	19	8	8	91
17	20	1	1	78	32	12	8	8	92
12	7	1	1	2	42	12	8	8	93
19	15	1	1	43	52	12	8	8	94
16	15	1	1	55	52	11	8	8	95
9	11	1	1	36	52	11	8	8	96
8	17	2	1	53	73	11	8	8	97
16	15	2	1	59	73	12	8	8	98
17	15	2	1	72	73	12	8	8	99
7	12	1	2	46	11	11	8	8	100
16	19	2	2	53	41	11	8	8	101
15	19	2	2	74	51	13	8	8	102
15	12	2	2	26	72	11	8	8	103
21	16	1	1	54	42	12	7	7	104
14	14	2	1	53	73	11	7	7	105
8	5	2	1	7	73	12	7	7	106
16	19	1	2	73	11	11	7	7	107
10	16	1	2	26	11	11	7	7	108
15	18	2	2	45	72	12	7	7	109
9	14	1	1	1	32	11	6	6	110
10	16	1	1	76	42	12	6	6	111
13	8	2	1	15	61	12	6	6	112
14	12	2	1	2	73	12	6	6	113
14	19	2	2	86	41	11	6	6	114
14	17	2	2	78	51	11	6	6	115
11	10	2	2	36	51	11	6	6	116
12	14	1	2	25	71	12	6	6	117
15	11	2	2	83	72	11	6	6	118
20	23	2	2	99	72	11	6	6	119
14	16	2	2	27	72	11	6	6	120
19	16	2	1	40	21	12	5	5	121
17	15	1	1	39	42	12	5	5	122
•	9	1	•	31	•	13	5	5	123
10	15	2	1	42	61	12	5	5	124
13	13	2	1	21	61	12	5	5	125
8	7	1	2	15	11	11	5	5	126
19	17	1	2	93	11	12	5	5	127
17	12	1	2	31	11	12	5	5	128
16	14	1	2	35	31	11	5	5	129
16	12	1	2	•	31	11	5	5	130
16	12	2	2	19	51	11	5	5	131
18	11	1	2	77	71	12	5	5	133
134	1	2	2	89	72	12	5	5	134
135	2	2	1	9	21	11	4	5	135

OBS	O1	S	GR	SC	IT	M	T	O2	O3
136	4	0	11	32	3	1	1	6	10
137	4	0	11	52	61	1	1	13	19
138	4	0	10	52	1	1	1	7	8
139	4	0	11	61	24	1	2	15	15
140	4	0	10	73	11	1	2	4	3
141	4	0	11	11	26	2	1	16	12
142	4	0	11	11	33	2	1	9	7
143	4	0	11	11	26	2	1	8	9
144	4	0	11	31	18	2	1	7	6
145	4	0	11	31	22	2	1	12	9
146	4	0	11	41	34	2	2	11	11
147	4	1	12	72	72	2	2	20	21
148	3	0	11	21	20	1	2	10	16
149	3	0	10	21	1	1	2	13	9
150	3	0	10	21	80	1	2	19	16
151	3	0	12	52	29	1	1	17	15
152	3	0	11	52	38	1	1	11	15
153	3	0	10	52	74	1	1	18	16
154	3	0	11	73	.	1	2	11	8
155	3	0	12	11	45	2	1	11	11
156	3	0	12	11	38	2	1	15	11
157	3	1	11	31	4	2	1	13	7
158	3	0	11	31	19	2	1	10	18
159	3	0	10	51	55	2	2	10	16
160	3	1	12	71	39	2	1	10	11
161	3	1	12	72	15	2	2	12	13
162	2	0	12	52	56	1	1	14	18
163	2	0	11	52	30	1	1	8	12
164	2	0	11	11	39	2	1	12	9
165	2	0	11	41	71	2	2	16	21
166	2	0	12	51	.	2	2	8	10
167	2	0	10	71	48	2	1	13	13
168	2	0	10	71	69	2	1	17	16
169	2	1	12	71	10	2	1	16	12
170	2	0	12	72	52	2	2	16	16
171	0	0	12	31	3	2	1	8	9
172	0	.	.	41	.	2	.	10	11
173	0	.	11	41	40	2	2	15	14
174	.	0	11	32	18	1	1	10	16
175	.	0	12	42	35	1	1	17	10
176	.	0	12	42	76	1	1	19	18
177	.	.	.	41	.	2	.	10	10